DISCOVERY

Monthly Note Book
DAVID S. EVANS, M.A., Ph.D., F.Inst.P.

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Museum Technique

Night Sky in October
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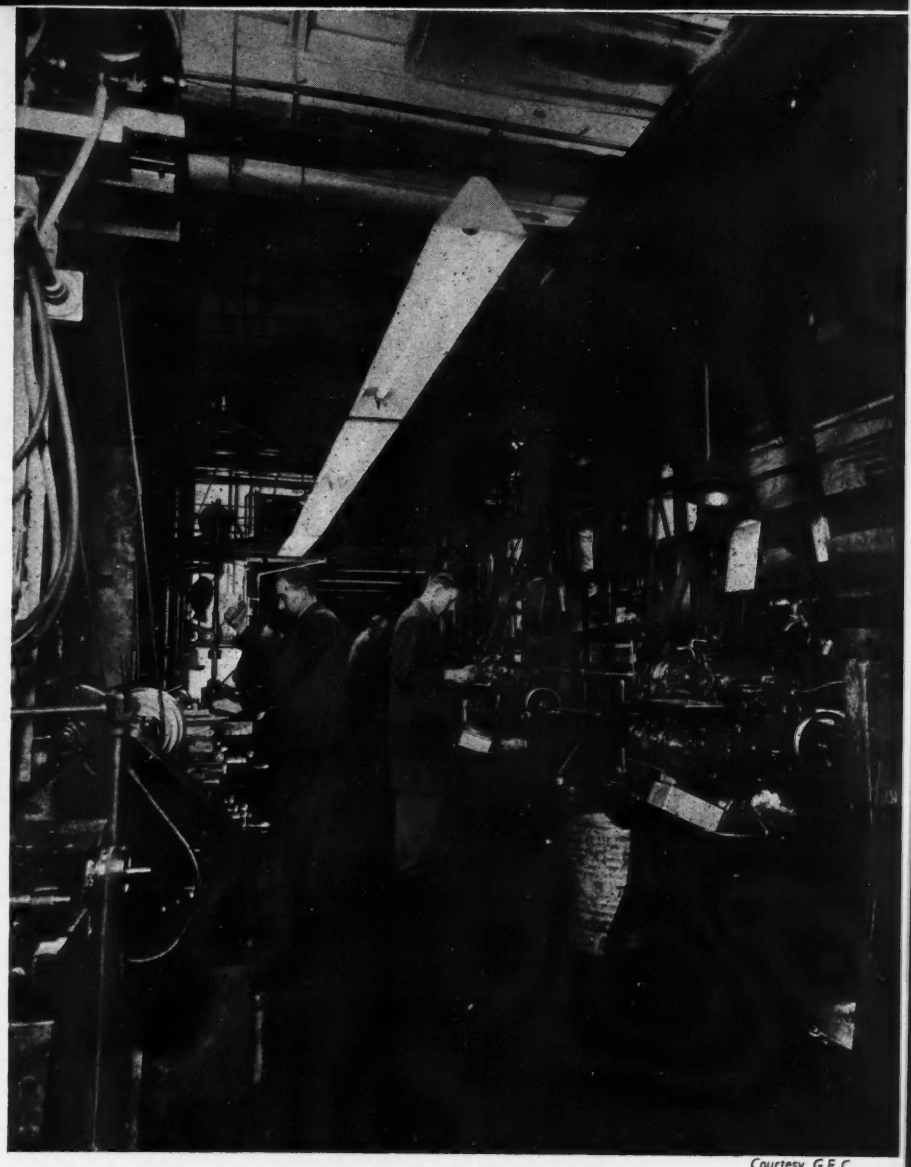

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DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Plans and Planners

"PLAN" has become a witch word arousing violent emotional reactions which destroy the possibility of reasoned thought. A bewildering variety of plans of all kinds has appeared: their protagonists and opponents assault each other in print, and bandy words such as "freedom", "bureaucracy" and "individualism" until almost all the meaning is beaten out of them. Let us invoke the spirit of Susan Stebbing and endeavour to think about planning to some purpose.

In the last analysis a plan means nothing more than having some idea of future intentions. To lack all plan is to descend to the haphazard—to hit the ball with closed eyes, or to arrive at the concert having used the score to wrap up the fish and chips. Evidently the fiercest opponents of planning do not contemplate a descent to this happy-go-lucky state of affairs. Even the most rabid individualist must recognise some social sanction, even if they are nothing more than the rules of solitaire or patience.

The problem is, then, that of the degree to which our activities shall be determined by some kind of plan. The opponents are separated by a difference of emphasis rather than by a disagreement on principle.

However, besides deciding "How much plan" we must also settle who is to make the plan and what its objects are to be. It is here that the fiercest battles rage, and here that the same thing is called by a variety of names. When the same brickbat may be labelled "well-planned organisation" and "rigid bureaucracy" the easiest test of correctness is to examine the motives of those who tie on the labels. It may be unkind to describe an individual list as "one who wants to make the plan himself", but there is enough of this spirit in the air to warrant a cautious examination of the fundamental principles of planning in a democracy.

Democracy rests on the assumption that society should be so organised as to permit the fullest development of all the individuals who comprise it, and further supposes a general education in the implications of this assumption, so that, for example, the individuals concerned can, from time to time, freely agree to combined action for the good of the whole community. It is thus from the community as a whole that the sanction for a democratic plan must proceed. This is not an unrealisable ideal, as has been amply demonstrated by the widespread interest and support that has been accorded to the Beveridge Plan. The process by which that plan was produced seems to be the ideal one. First the technical details are worked out by experts in the field, and then the finished product must somehow be made available for general discussion.

In this particular case there was no need to arrange any special mechanism for the expression of the public will, which spontaneously arose, sweeping aside all obstacles in its path.

The criterion for judging plans is then simple enough. Does the plan express the will of the community as a whole? If it does, then, provided it be technically sound, it is the expression of a sturdy democracy in which all the individuals agree to devote their individuality to a common cause. Our other questions then answer themselves: the community makes, or rather approves, the plan; and the purpose of the plan is to further the interests of the community as a whole.

Most of the classic objections to planning then become irrelevant. The traditional red-tape and lack of initiative associated with government control, which are of course exaggerated or neglected as convenience suggests, are adventitious features arising from an imperfect popular control of the administrative machine. Like the reports of the death of Mark Twain, these features are much exaggerated—for example in the case of certain medical opponents of the Beveridge scheme, who proceeded on the tacit assumption that the moment a doctor became a state employee, all his professional devotion and enthusiasm would magically vanish away. Woe betide the layman who would dare to express such a slanderous view!

Planning, insofar as it is a rational attempt to use available resources efficiently, is a scientific process. With

the social aspects of planning, scientists are concerned as citizens, but with the technical aspects their concern is professional. A note of warning has recently been struck by a letter over the name of three signatories representing the Joint Council of Professional Scientists, who express the opinion that estimates as to the economic benefits which might accrue from a fuller application of science have been much exaggerated. In estimating the value of this contention it is useful to read it in conjunction with two planning documents recently issued. One is the Parliamentary and Scientific Committee's Report on Coal Utilisation in Great Britain. The other is a pamphlet by Mr. W. C. Devereux, Chairman of High Duty Alloys Ltd., entitled *The Post-War Reconstruction of Industry in South Wales*. Both are deeply concerned at the inadequacy of existing methods of using our most important mineral asset, and both stress the urgency of developing large scale research programmes; but Mr. Devereux's discussion goes further, and plans in some detail how a coal products industry and an alloy industry could be established in South Wales. He has also some interesting remarks to make concerning the establishment there of a plant for the extraction of metals from sea-water, and some observations on the combination of a scientific agriculture with existing industries.

While some of Mr. Devereux's remarks concerning the labour situation are likely to arouse opposition, and although his discussion is confined to industries in which he himself is concerned, the important point, in view of the Joint Council's contention, is that an experienced business man regards the planned scientific development of South Wales as a sound proposition capable of maintaining the standard of living of the whole region at least at its pre-war level. This view from such a source is significant, since we can hardly describe Mr. Devereux as a hot-headed revolutionary in spite of the fact that at one point he judges the proposition against what might be done in Russia.

The same criterion for the judgment of plans must be applied to the planning of science itself, only here two democratic communities are concerned: the society which is going to pay for the scientific work, and the scientists who are to carry it out. Looked at in this way, as is done for example in *The Planning of Science* published by the Association of Scientific Workers, planning is not an external dread compulsion, but a freely concluded agreement in the interests of efficiency, and the avoidance of omission and needless duplication.

In this field, as in all others, the apparent contradiction between freedom and planning can be resolved. Here we have much to learn from our Allies, the U.S.A. and the U.S.S.R., and as Mr. Devereux's aside seems to suggest, especially from the latter. There a successful solution seems to have been found and a close approach made to the democratic ideal of a society of individualists.

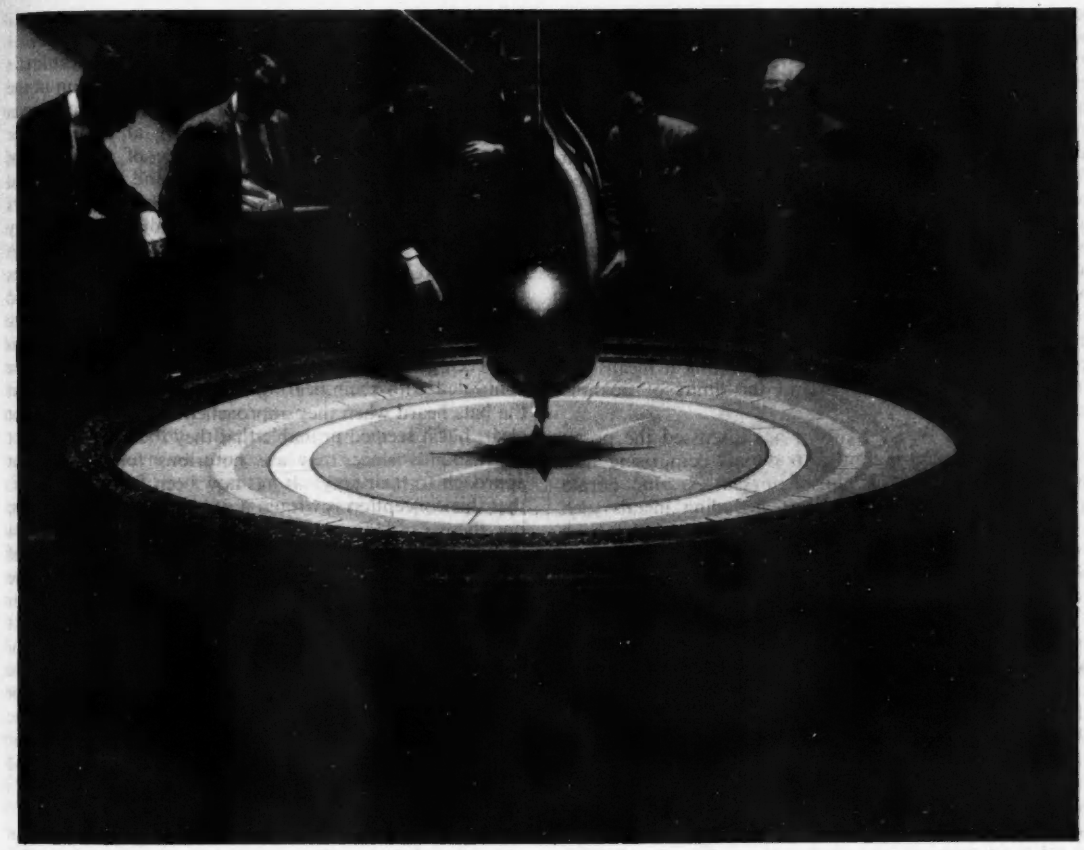
The Rotation of the Earth

For many astronomical purposes it is a matter of indifference whether we think of the earth as rotating and the directions of the stars as fixed, or whether we adopt a completely mundane view point and regard the earth as fixed and the stars as moving past us. In most cases the only criterion is simplicity of treatment, but there are a few instances in which the rotation of the earth on its axis can be demonstrated directly. Such instances arise because the laws of nature require to be expressed slightly differently if we persist in making all our measurements with reference to terrestrial standards. This type of description is known technically as using a rotating system of reference, and of course, if we are describing the flight of an aircraft, or the movement of a ship, a system of reference rotating with the earth is the natural one to use. It is of considerable interest to us to know that a ship is on the equator and moving south at thirty knots. The addition of a velocity of 1000 miles per hour eastwards, and 18½ miles per second perpendicular to the line joining the earth to the sun would give the total velocity of the ship relative to the sun, but few mariners would find it of any practical value.

So wedded are we, both for theoretical reasons and practical convenience, to our rotating system of reference that the slight differences of expression of the laws of mechanics which arise in such a system are attributed to the action of forces created in our minds for the purpose. One of these is the Coriolis force, which is put in to account for the fact that a falling body such as a bomb deviates slightly eastwards as it drops. The deviation is not much—only about an inch in 300 feet on the equator—but it is of importance in long-range artillery calculations. The interesting thing is that the deviation is to the east, and not to the west. After all the earth is rotating towards the east, so that one might have expected that while the bomb was on the way down the earth would have rotated a little towards the east, thus bringing the bomb to earth a little to the west of the point over which it was released. The fallacy in this argument is that although we have assumed the bomb to be dropped from an airship or a helicopter at rest over a particular target, the fact that the earth is rotating means that aircraft, bomb, and target are all moving at a very high speed. One of the laws of motion leads to the result that the sideways speed of the bomb multiplied by its distance from the axis of the earth must be constant. Hence if the latter decreases, the former must increase, and so the bomb as it falls moves sideways slightly faster than the surface of the earth, landing just a little to the east of the point directly beneath the point of release.

Naturally the Coriolis deviation is difficult to demonstrate experimentally, but there is another mechanical demonstration of the rotation of the earth which is frequently shown in museums and teaching laboratories. A carefully constructed pendulum consisting of a wire and a bob will swing in the same plane, not as judged from the earth but as judged by the fixed stars. If the pendulum is really well constructed so that the suspension does no more than suspend, exerting no twist on the wire of the pendulum, then the pendulum will go on swinging in the same plane, while we, on our rotating system of reference to which we are so much attached, turn round the pendulum. To us, therefore, it will appear that the plane of motion of the pendulum bob will turn, executing one complete revolution in the time which the earth takes to rotate once on its axis.

This experiment is associated with the name of Léon



Foucault (1819-68) who in the year 1851 set up the pendulum experiment at the Panthéon in Paris. He used a layer of fine sand and a needle attached to the pendulum bob to mark the direction of its motion. Foucault's name is associated with a number of experiments designed to demonstrate the earth's rotation mechanically, and it is to him that we owe much of our knowledge of the properties of rotating flywheels, of the kind used in gyro-compasses. They are useful as indicators of directions because of their stability, and indeed some of the difficulties connected with the design of gyro-compasses are concerned with the fact that a gyro-compass tends to point to the same direction in space rather than to the same point on the earth's surface. Foucault was much interested in these problems and it is to his coinage that we owe the word "gyroscope."

Foucault's name is also connected with early work on the identification of chemical composition by spectral analysis, and with that other great French pioneer of physical optics, Fizeau, he made, in 1845, the first photograph—a daguerrotype—of the sun. Later, in 1862, their names were associated with independent determinations of the velocity of light, Foucault's value of 298,000,000 metres per second being within 1% of the true value.

The photograph shows the Foucault pendulum set up for demonstration purposes at the Chicago Museum of Science and Industry. The supporting wire is 65 feet in length, and the bob, which is made in two halves very accurately machined and screwed together, weighs 350 lb. Beneath the bob can be seen the large dial which serves to indicate the rotation of the plane of oscillation of the pendulum bob.

Materials for Optics

A recent reference in DISCOVERY to the use of plastics for making contact spectacle lenses produced many inquiries from readers. Workers in various branches of the optical industry are keeping an equally watchful eye on the development of new optical materials and their possible applications. It is recognised that the provision of optical materials satisfying certain requirements of durability and freedom from scratching, coupled with useful characteristics of absorption and dispersion in regions of the spectrum not easy to reach at present, may produce great advances in theoretical physics.

The development of glass itself is a striking example of the way in which fundamental scientific knowledge waited upon technical development, and how in the end, when it was possible to manufacture large and accurate

lenses, mirrors and prisms, the new fields of research which were thereby opened up yielded an abundance of knowledge which is often, rather unimaginatively, classed as "pure" scientific knowledge. However, the possibilities of glass are rather limited. It will not transmit even the near ultra-violet wavelengths of the spectrum, and its dispersive powers at the red end of the spectrum fall away very rapidly. Investigations have been pushed beyond these limits in the one direction by the use of quartz which transmits in the ultra-violet, and in the other by the use of rocksalt prisms. In the latter case, however, the usefulness of the instruments has been limited by the available size of the naturally occurring rocksalt crystals, and by their sensitivity to moisture and general fragility. So the search for new optical materials goes on, in an effort to provide the technical means for the researches which will extend the limits of possible investigations.

Recently Mr. B. K. Johnson has discussed the possibilities of a variety of optical materials comprising new types of glass, such as phosphate glasses, zinc borate glasses, and a variety of glasses including metals such as zirconium, titanium, and tungsten. The latter have very high refractive indices which offer considerable possibilities in the simple construction of fully corrected compound lenses.

The plastics which have optical possibilities include Perspex, Bexoid, Celastoid, Distrene, Polystyrene and Xylonite. One advantage which they possess is that they can be moulded in very accurately shaped metal moulds, thus dispensing with the necessity of figuring and polishing the surfaces subsequently as in the case of glass, but they have the disadvantage that they are rather soft and tend to scratch easily. Perspex and Polystyrene, however, seem particularly promising, for both transmit well in the ultra-violet, and although they absorb in the near infra-red they are transparent to long-wave infra-red radiation.

One of the most interesting topics discussed by Mr. Johnson is the manufacture, now developed commercially in the United States, of artificial crystals of various salts. These include Sodium Nitrate, Potassium Bromide, common salt and Lithium Fluoride. The method used is most ingenious and consists in building up the crystals continuously by the use of a pair of electric furnaces. The upper furnace is maintained at a temperature above the melting-point of the salt in question, and a platinum crucible with walls only a few thousandths of an inch in thickness containing the molten salt is lowered at a very slow, uniform rate through a hole in the bottom of the upper furnace into the lower one. The latter is maintained at a temperature below the melting-point of the crystals, so that as the crucible passes into the lower furnace the salt in it starts to solidify and a crystal is steadily built up. It may take up to ten days to grow a big crystal, during which time the rate of movement and the temperatures of the two furnaces have to be controlled with extreme precision. Even after the crystal is formed it has to be annealed for seven or eight days at a temperature within 50 C. of the melting-point, but the results are well worth the technical care involved. Some of the crystals are 10 inches in diameter and weigh 25 lb., which is much larger than any specimens occurring naturally, and in addition the artificial product is more homogeneous than the natural.

Blind as a Bat

In spite of the proverbial blindness of bats, these animals are known to possess a faculty of aerial navigation in the dark which would make many a seasoned airman green with envy. Their extraordinary ability at finding their way about, without making much use of the sense of vision, has stimulated speculation and experimental research for a long time. Indeed early investigators who blinded bats completely found that their ability to navigate was hardly impaired at all. The question arises as to the nature of the mechanism which enables the bat to avoid obstacles which he cannot see, and an answer to this question has recently been given by experiments carried out in America. The impression had been gained that the bats' skill in flying was somehow connected with their hearing mechanism, although what the bats heard when they approached an obstacle was not clear, but it seemed probable that they themselves did not emit sounds since bats are notorious for their silent approach to their prey. It has now been found, however, that this conception is wrong; indeed bats do emit sounds, but these sounds are supersonics, i.e. sounds of such a high frequency that they lie well outside the range of notes perceptible to our ears. The notes emitted by the bats are complex sounds like those produced by animals and humans in the normal acoustic range, but composed of components which lie two octaves above our range of hearing. It was found that these supersonic sounds were produced in the normal way by the animal's throat and not by an entirely different mechanism, for submerging the bat except for the head did not alter the intensity or nature of the sounds appreciably. Similarly it could be shown that the sounds were picked up by the bat's ear.

It is now clear how the bat is able to avoid obstacles in its path of flight. The supersonics emitted from his throat do not return to his ear except when they are reflected by an obstacle, so that the bat has to listen for an echo of his supersonic voice, which will tell him that he has to alter course. This method of echo sounding has actually been employed for several decades in a number of devices designed to assist sailors and aviators by indicating the depth of the sea, or the height of the aircraft above ground. The great advantage of echo-sounding for sea navigation is that it eliminates the tedious and dangerously slow process of swinging the lead, and it can easily be applied to depths where a normal lead line could not easily reach. Its advantage over the normal aircraft altimeter is that it indicates not the height above sea level, but the height above ground, a difference which is of vital importance over mountainous country.

The experiments which clinched this view of bat navigation consisted in observing the flight of bats through a room with acoustically non-reflecting walls, in which a number of wires were suspended from the ceiling. The number of wires which were hit by the bats when crossing the room was registered. It became quite clear from a large number of tests that the navigational ability differed markedly from bat to bat. The clumsiest bats hit the wires as often as they would have done if they had had no warning apparatus, but this may be an unjustified calumny on their prowess, since the wires which were used to

trip them up constituted much more tricky obstacles than any which are likely to be met with in nature.

It may be that human beings can develop a similar faculty, for we have all seen blind men who can walk parallel to a wall without ever touching it.

Protecting the Grid

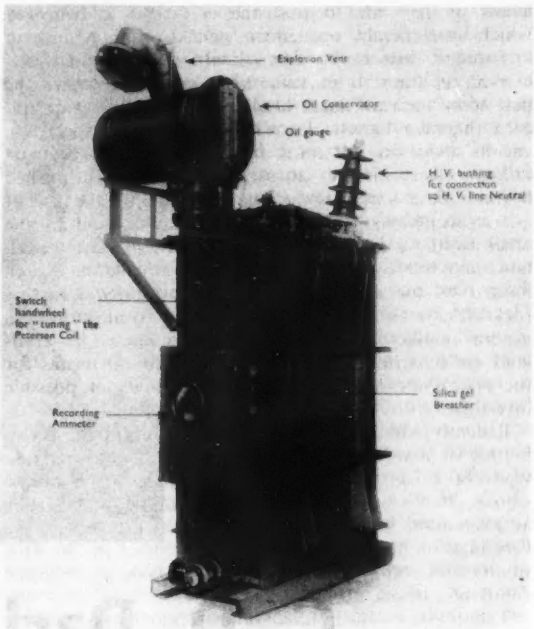
THE technical problems associated with the long-distance transmission of electrical energy are very considerable. The energy is transmitted in many cases as three-phase current. This phrase means that the potential applied at one end of the line is not constant, but variable. However, this variation is not a simple oscillation of the applied voltage with time, as it is in the case of a simple alternating current. The variation is in fact composed of three such simple oscillations, equal in magnitude, and placed equally out of step with each other.

From time to time faults occur in the transmission equipment, which usually consist in a momentary short circuit of one of these three phases only to earth. However, although such faults are only momentary, they may easily develop further and do permanent damage. What happens is that during the original fault, the air through which the fault occurs is ionised, that is, the atoms of the air acquire an electric charge. If these are not dispersed they are liable to provide an easy pathway along which an arc can be formed by the whole energy of the circuit, and this may easily lead to damage to the line and an interruption of the supply.

A very ingenious and simple device has recently been invented by Professor Petersen which prevents these larger developments of small faults by suppressing the formation of the arc. Here and there in the complex circuits of modern electrical engineering there are points which, when the circuit is working properly, are neutral. They are neutral because, if the three phases of the current are in proper balance, their effects always just cancel one another. However, if a single-phase fault occurs, which throws one of the phases out of balance, such a point will no longer remain neutral, but will be raised to a potential equal to the phase voltage, above earth. This equality is due to the fact that the fault has temporarily removed one of the phases, and the remaining two, which by themselves just balance the third, are now out of balance by an amount exactly equal to the missing third voltage.

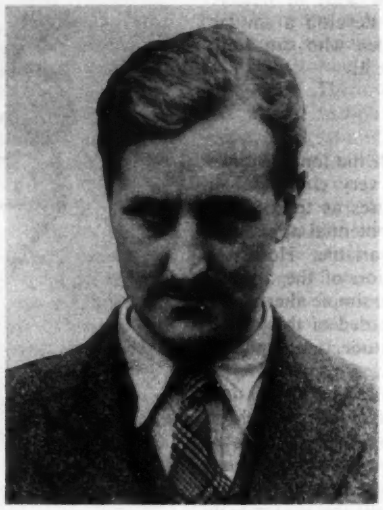
The arc suppression coil is simply a specially constructed coil connecting such a neutral point to earth. When the circuit is functioning properly, both ends of the coil are neutral, but when a fault occurs in one of the phases, one end which should be neutral is raised to a potential equal to that of the phase which has been momentarily knocked out. The coil then forms one part of a circuit which is completed through the temporary fault, and it is designed in such a way that the sudden surge of current through the fault is exactly balanced by the current induced in the arc suppression coil. The effect of this is to balance out the currents in the temporary circuit so formed, and to prevent the formation of an ionised path along which a serious arc might develop.

The coil is also designed so that when the temporary fault corrects itself, the return to normal conditions is a gentle one. If the coil did not have this stabilising property, the return to normal would be just as sudden and probably just as damaging as the original fault. Such coils work extremely well, and although it is often difficult to secure exactly the right balance, the coil has often proved effective in suppressing arcs even when it is as much as 25% out of tune, and the danger of supply interruption is reduced by the inclusion of the device to about one tenth. Even if the fault is a permanent one, the effect of the coil is to neutralise it until such time as it may conveniently be repaired. The actual details of construction are of course considerably more complicated than has been indicated here.


Explosion Vent
Oil Conservator
Oil gauge
H. V. bushing for connection to H. V. line Neutral
Switch handwheel for "tuning" the Petersen Coil
Recording Ammeter
Silica gel Breather

Courtesy of the Hackbridge Electric Construction Co., Ltd.

The arc suppression coil shown in the photograph is insulated for use on a 33,000-volt line, and has a current range from 26 to 50 amperes in 2 ampere steps. There is one 33,000-volt oil-filled porcelain bushing which is connected to the neutral point of the system, and another small bushing for the permanent earth connection. The tank is filled with oil and there are devices to allow for the expansion of the oil due to the heat produced when the circuit is carrying a load, and also to ensure that only dry air comes into contact with the oil. If an internal fault occurs in the tank leading to the formation of gases this fact is automatically indicated, and there is a pressure relief vent adjusted to blow out at a pressure of 10 lb. per square inch. A current transformer is also provided to measure the current in the coil, and this is set to operate an automatic time relay if the current persists for more than a certain length of time. The object of this is to keep the coil in action if the fault is a permanent one, and thus to protect the line until it can be repaired.



Wimbledon Boro News

C. D. Darlington, F.R.S.

DIRECTOR OF THE JOHN INNES HORTICULTURAL INSTITUTION

ONE of the most fluid fronts on which science is advancing is that to which Bateson gave the name of "Genetics". Spectacular progress is being made in this sector, which is attracting the attention of many of the most enterprising biologists; but as this field of study is generally looked upon as being highly specialised—it is still virtually outside the ordinary university curriculum for instance—the names of the majority of these scientists are known only within a comparatively small scientific circle. One of the men who have won international repute for discoveries on the genetics front is Dr. C. D. Darlington. A fellow biologist gives us this thumb-nail sketch of Darlington: "He is not very interested in anything outside the cell nucleus, but the things within it, which are the most fundamental structures in living things, he understands better than anyone else. At first sight one might wonder if he were a High Church curate or a cavalry officer, but you would soon find that he has the most robustiously creative imagination in British biology." Apart from the fact that cavalry officers are obsolete, which Darlington most certainly is not, it is a neat description.

Outside the Syllabus

Darlington—his initials stand for Cyril Dean—is director of one of the most important research stations in the world concerned with plant breeding—the John Innes Horticultural Institution. He succeeded Sir Daniel Hall to this post at the early age of 35. The importance of his researches has brought him the distinction of being elected an F.R.S. before his 40th birthday and his prominence among geneticists has led to his election this year as president of the Genetical Society. Yet, if in his student days he had kept the examination blinkers clapped tightly to both eyes and stuck to the straight and narrow path of textbook reading imposed upon students by university syllabuses, he might to-day be running a farm with never a worry as to whether a plant was a diploid or a tetraploid and blissfully ignorant of the microscopic machinations of the chromosomes. For his boyhood ambition was to become a farmer in Australia.

Darlington was born at Chorley, Lancashire, in 1903. His father, a schoolmaster who taught science among other subjects, sent him to the Mercers and St. Paul's schools, and when his son decided he wanted to make a career in agriculture, he gave him the opportunity of taking a good agricultural degree at Wye. But as I have already suggested, Darlington read a little outside the college curriculum, and in so doing came across some of the research papers of the great American zoologist, Morgan. He became so interested in the newly-discovered facts connecting genetic factors with the chromosomes that he came to the conclusion that it was here, at the point where genetics and cytology meet, that he should specialise. Once decided upon the subject he wanted to study, there was no doubt in his mind that the next step was to get to the John Innes Institution, then virtually the only centre in England offering facilities for this kind of research.

A vacancy on the staff was advertised and Darlington lost no time in applying for it. He received an answer from Bateson, who was the director, asking him what sort of research he wanted to do and how he proposed to set about carrying it out. Not unnaturally, being only

20 years of age, he had no very clear ideas on the second question, and admitted as much in his reply to Bateson. However, he managed, with some difficulty, to secure an interview, in which he must have convinced Bateson that he was qualified to assist in the kind of work the station was doing, for the outcome of the interview was that he was allowed to join the select band of scientists at Merton Park. True, for the first four months he gave his services without pay, but at the end of that period he was appointed to the staff. That was in 1923.

Research at John Innes

The John Innes Horticultural Institution is a remarkable place. Its laboratories and experimental plots are situated in Merton Park, a typical characterless London suburb without even a postal number to call its own; indeed its only living claim to international fame lies in the existence of the research station which takes its name from the late Mr. John Innes, a man who left his fortune "for the improvement of horticulture", although he had no particular interest in science. The council of nine appointed under the Charity Commissioners to administer the estate concluded there were two ways in which the terms of the will could be carried out; one was to provide the means whereby gardeners could receive a sound training, which is still one of the functions of the institution; the other was to establish a station where research into plant breeding could be carried out.

As its first director, the council picked a man whose ideas obviously had something new to offer in the line of breeding better plants and animals. Their choice was William Bateson, the man who coined the name "Genetics" for the new science of variation and heredity. Bateson's studies in zoology and natural history had led to his becoming more and more interested in evolution and over many years he had been collating facts about variation and heredity. In 1900 the re-discovery of Gregor Mendel's papers that contained the theory of Mendelism which the Abbot of Brno had deduced from breeding peas in his monastery garden, gave Bateson the clue he needed, the hypothesis which he himself was on the verge of formulating from the results of his own investigations. He was immediately attracted by Mendel's work and translated the papers which had for so long languished in oblivion in the unread journal of Brno's local natural history society; when Mendel's laws met with hostile criticism he took it upon himself to defend the theory against all comers. It was largely Bateson's campaign, and in particular his book *Mendel's Principles of Heredity*, that led to the general acceptance of Mendelism by scientists in the English-speaking countries. Mendel had postulated a mechanism by which characters come to be inherited, and had established with great clarity the concept of genetic factors. Now, since the germ cells of both animals and plants consisted almost entirely of nuclear material, it seemed almost certain that these factors must reside in the nucleus of cells and not in the cytoplasm, and the stage was set for cytologists to bring their special techniques to bear upon this problem. In America, Morgan was able to prove to the satisfaction of scientists all over the world that the ultimate carriers of genetic factors—the genes—were the chromosomes. Morgan's chromosome theory provided a logical explanation of the way in which arose the ratios—"one white, one black, two khaki" and so on—which Mendel and others had obtained in breeding experiments. Moreover, by an ingenious piece of reasoning, Morgan was able to reach the conclusion that the genes were dotted, so to speak, along the length of the rod-like chromosomes, and from this postulate he developed his chromosome maps on which the relative positions of the different genes were plotted. It was this work which attracted Darlington in his student days.

When Darlington joined the staff of John Innes there was something of a deadlock between Batesonian and Morganian genetics, for though Bateson had been quick to appreciate the fundamental importance of Mendel's ideas, he did not find it easy to accept Morgan's theories. It is greatly to Bateson's credit that he kept an open mind about the new developments, so that when he went to America Morgan and Bridges (Morgan's assistant) succeeded in convincing him that investigations into the chromosomal mechanism of inheritance should be started at John Innes. To that end he formed, on his return to this country, a cytological department with W. C. F. Newton in charge. Darlington, who had been working with M. B. Crane on the breeding of fruit trees (which remains as Darlington's second greatest interest in genetics), became Newton's solitary pupil. Newton's abilities were soon to be lost to science through his untimely death in 1927 at the age of thirty-three, but in the few years which remained to him he left his mark on cytological progress, developing a number of important new techniques, outstanding among which was his method of staining chromosomes with gentian violet which was quickly adopted all over the world. On his death, Darlington, then only twenty-four years old, was left responsible for this branch of the station's activities. While referring to the cytological work done at John Innes, I should mention L. F. La Cour, who joined the station as a laboratory assistant a year or two before Darlington. No small share of the credit for recent improvements in the art of fixing and staining chromosomes should go to him, and if you are interested in this side of the subject you cannot do better than read the book which he and Darlington published last year entitled *The Handling of Chromosomes*, and which was reviewed in last month's DISCOVERY.

Bateson died in 1926, and he was followed as director by the late Sir Daniel Hall. Meantime Darlington was collecting an amazing number of new facts about the behaviour of chromosomes, and building bold and original theories on these facts. In his first book, *Recent Advances in Cytology*, he re-arranged all the facts known about chromosome behaviour in the light of his own ideas. A few people praised the originality of this book, but in general it was received at home and abroad with disapproval on account of its startling speculations.

A Widely-travelled Scientist

In connection with his scientific work Darlington has made several visits abroad to meet and discuss developments with leading foreign geneticists and cytologists. In 1929 he travelled through Persia and Transcaucasia, one of the highlights of this journey being his call at

Vavilov's fruit research station at Sukhum; it gave him great satisfaction to see the Russian's proof that the domestic plum had its origins as a cross between the sloe and the cherry plum, a fact which fitted in with deductions which Darlington and his colleagues had drawn from the chromosome numbers of the three plants—in other words the Russians by synthesising the domestic plum (they had also found the hybrid growing wild in the Caucasus) had confirmed the results of chromosome analysis carried out at John Innes. It is of interest to note that Vavilov, who is—or was until recently—the doyen of Russian plant breeders, trained under Bateson at Merton Park in the years 1913 and 1914. After the Revolution he was appointed director of the Leningrad Academy of Agricultural Science, a post which placed under his control an enormous organisation of 300 research institutes, with staffs totalling 18,000 persons. On Darlington's second visit to Russia in 1934 he called on Vavilov at the Stroganoff Palace in Leningrad from which he used to direct this vast enterprise of research into economic botany, the greatest undertaking of its kind in the whole world. While in Moscow Darlington was the star artist of a "midnight matinee" held by the Academy of Sciences, lecturing the academicians from 9 p.m. to midnight on his theory of what is called "crossing over" between chromosomes. Between these two trips to Russia Darlington had been to America, where he worked in Morgan's laboratories, and also spent some time collaborating with Belling, the pioneer of plant cytology in the States. His tour of America was a part of a trip round the world that also enabled him to meet plant breeders and to see how cytology was being applied in Japan and India. In 1937 he visited India again, this time with the British Association; on this voyage he wrote one of the few scientific treatises that have been written on shipboard; the book, which he considers his most important work, is entitled *The Evolution of Genetic Systems* and was published just before the outbreak of war. At the end of last year Darlington undertook a cultural mission for the British Council, a lecture tour of Sweden. The proposal that he should go to Sweden originated with the Mendelian Society of Lund, Darlington's work being better known in Sweden than anywhere else in the world (including Britain!); incidentally the last-mentioned fact explains perhaps why he considers that in many respects Sweden leads the world in plant breeding.

The Importance Of Genetics

Genetics has made great strides during recent years, and to the development of this science Darlington has made important contributions through his discoveries and his theories. Cytological work of the kind he is doing is fundamental research, offering as it does the key to the genetical constitution of existing plant material and suggesting how in future plant breeders will be able to "mark the cards" before carrying out the shuffling and re-shuffling of the packs of chromosomes which occur in repeated hybridisations. It is the cytologists who have revealed the possibilities of inter-specific crossing, which is itself a contradiction of the old definition of a species under which cross-breeding could take place between varieties but not between species, inability to cross-breed and produce fertile offspring then being the arbitrary criterion of specific difference. Now that the chromosome mechanism of breeding is so well understood it is possible to take advantage of the discovery that colchicine in suitable concentrations can cause doubling of the chromosome number; the scientific exploitation of this technique is likely to speed the production of new and useful plant varieties and yield spectacular results in the next decade or so.

Dr. Darlington, like his former chief, Sir Daniel Hall, is keenly interested in the social relations of science. He is much in demand as a speaker, and during this year the audiences of several scientific conferences have gone home impressed with his ready wit and his mordant comments. I cannot resist the temptation to quote the following Darlingtonism, made at the "Planning of Science" conference: referring to the lack of co-ordination between British botanical science and the agriculture of the British Empire he said, "We have two elaborate organisations concerned with the study of plants which grow in our tropical possessions—Kew Gardens and the Natural History Museum. Kew has 5,000,000 dried specimens, and the Natural History Museum 4,000,000. They have no connection with each other and they have no connection with experimental science either here or in the colonies. The director of Kew Gardens is responsible to the Minister of Agriculture, and the director of the Natural History Museum to the Archbishop of Canterbury. I do not know if these two gentlemen ever meet; if they do, I am quite sure they do not talk about botany". He has done a good deal of broadcasting. He holds decided views about the popular exposition of science, and he evidently does not consider that the B.B.C. can be given full marks for its efforts in this direction, judging from his speech to a recent British Association meeting.

He intensely dislikes almost all organised sports, and he finds his relaxation in walking and gardening. The most intriguing plant in his garden is a creation of John Innes; it is the thornless blackberry, the outcome of twenty years cross-breeding. (Readers may be interested to know that it comes on the market this autumn; it will be sold direct from the research station, and the profits will go "back into the business.")

Dr. Darlington's wife is the eldest daughter of Sir Gilbert Upcott, comptroller and auditor-general of the Exchequer and Audit Department.

Explodes faster than TNT

"CYCLONITE, a new explosive for bombs and shells, explodes even faster than TNT," declared Alberto F. Thompson, assistant professor of chemistry at Massachusetts Institute of Technology, in a recent address at Schenectady, N. Y. "Nitroglycerine and dynamite are too sensitive and hazardous for explosive bombs and shells," said Dr. Thompson. "In 1870 it was found that coal tar yielded safer explosives of corresponding power. These are typified by picric acid and TNT. Shells or bombs loaded with TNT explode about 100 times faster than smokeless powder. New explosives like Cyclonite are even faster. Such materials exert the maximum destructive effect although their power is somewhat less than dynamite. At the same time they are very insensitive. The explosive used in naval shells, for example, can be fired through 16-inch armour plate without exploding if the fuse is set in the safe position. Similarly, bombs can be dropped safely if the need arises.

L.N.F.

FIG. 1.—Camouflage of the individual soldier. From the camouflage point of view most attention must be paid to the steel helmet, which must not be allowed to present a smooth reflecting surface. This can be achieved by means of a canvas or net cover that can be garnished with grass or foliage.

Camouflage: not solely an artist's problem

LIEUT-COL. C. H. R. CHESNEY, D.S.O.

THE object of camouflage is to delude. But whom? You and me, the casual observer, or the enemy in aeroplane or on the ground?

If, on regarding the external appearance of some object we are prompted to remark "Look at that camouflaged gun, tank, or pillbox", then it is normally fair to say that the object has been badly camouflaged. If, on the other hand, we pass it by without comment, then the probability is that it is good camouflage. Camouflage, like vitamins, is, paradoxically, only noticeable when it is deficient! Unfortunately during peace years, when camouflage could not be put to the test of battlefield practice, the subject developed an extraordinarily large fringe of charlatanry. Queer painting effects and curious juggling with light and shade made excellent subjects for illustration in the popular Press, the more unusual and bizarre the effects the greater their popular appeal. All too often it was these fantastic techniques which became identified in the public mind as the real thing.

A notable example of the limits to which public credulity can be stretched was afforded by pictures, published in one of our leading daily newspapers and in the journal of a most learned and artistic profession, showing certain large concrete structures bedaubed with paintings of immense fir trees; these photographs were described as showing "modern advanced camouflage"! This is a typical instance of deception of self, and self alone.

The necessity for careful and honest analysis of impression is not confined however to the visual effect. It is imperative that investigation should go a step farther, into the effects that will arise in war. Except among those who have battle experience this consideration is almost invariably overlooked. A good example of such distinction is provided by a detached building on the outskirts of

FIGS. 2 and 3.—The Binnen Alster area of Hamburg before and after camouflage.

The innermost of the two lakes in the heart of Hamburg has been camouflaged by means of huge floating rafts to represent a built-up area with a lay-out of street blocks, roads and a canal running through. A replica of the Lombardsbruck Bridge, the vital road and rail connection between the Binnen and the Aussen Alster, has been constructed about 600 yards north of the original bridge. This bridge is the link between the two main Hamburg marshalling yards. Fig. 2 shows the area before camouflage and Fig. 3 the same area after camouflage.

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a village, looking out over an expanse of terrain and offering a good field of fire. The window is there—not a real window, but the embrasure of a machine-gun post filled up with a removable picture representing perfectly the window with its proverbial white blinds and the geranium pot. Excellent camouflage—for illustrating a newspaper article! But of no value in reality. As soon as the machine-gun opens fire the enemy will locate it in the detached house, and in a few rounds artillery and mortar fire will have demolished so definite a target. On the other hand one may have a machine-gun or mortar post located behind some natural cover; it may not be difficult to see it from a distance of 100 yards or so, but it is almost impossible to locate it, either directly or by reference to any neighbouring object, at greater distances. When the great test comes this post will live and function long after that other within the house has been silenced.

Bearing in mind this propensity for camouflage work to develop a certain measure, honestly or otherwise, of self delusion (and indeed on occasion pure charlatanry) we may consider in broad outline the general story of the subject in the past, its possibilities in the future, and the direction in which progress is likely to take place.

The early days

Probably the first practical application of the art in modern warfare was the invention and perfection of the dummy tree as an advanced observation post for artillery, etc. Being an exact replica in form, texture and colour of the natural object which it replaced, this was an immediate success and fulfilled a very necessary requirement. Accompanying this production came the artillery net, made of fish netting and garnished with knotted pieces of dyed raffia or coloured canvas or scrim. This net was not a complete success either initially or at any time. In static warfare, aerial photography became so efficient at probing into enemy dispositions that it became almost impossible to elude the eagle eye of the camera.

As first made and used, in the form of careless draping over a number of plain poles erected haphazard round the gun, the shadows cast by the sag from the tips of the poles and by the sloping sides of the net revealed the attempted "secret"; particularly was this the case if the four or six guns were sited in regimental line and interval. Later, by gradual reduction of the quantity of garnishing towards the edge and by maintaining a rigidly supported flat net, it was hoped to avoid these tell-tale shadows. But without success. It became obvious that the gun with its attendant veil must be sited with reference to its surroundings, rather than relying upon the camouflage obtained by merely altering the veil to match its surroundings as far as possible. From this experience with artillery nets emerged the lesson that "form" is of paramount importance, far outweighing either texture or colour.

About the same time as the artificial tree and the gun net were introduced, there was devised the large coloured canvas sheet to cover dumps of ammunition, stores, etc., or any superficial groundworks that it was desired to conceal. These canvases were at first painted in the contrasting and disruptive style with black bands separating the colour masses in order to effect greater optical confusion. It was quickly learnt, however, that these patterns were very easily recognisable and were easily

This is a good instance of the futility of attempting to alter the map. The idea of the Germans was to draw the attention of the R.A.F. to the fake viaduct at the edge of the fake basin, the actual basin area having been hidden by giving it a typical pattern of houses and streets. Once detected the area calls for much more intensive action than would ordinarily have been devoted to it, and therefore the bad camouflage has done more harm than good. One solution of the problem would have been to divert the railway line through the shells of the buildings around the basin and so leave the map appearance intact. But it is all probably now devastated.

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detected among their surroundings by reason of the lighter patches which attracted attention. Furthermore, it became evident that the texture of these canvas sheets was too smooth and reflected too much light. Therefore they were discarded in favour of scrim sheets, of somewhat uniform coloration of dirty browns and greens and with which care had been taken to avoid uniformity of edges. It is not necessary to describe in detail any of the small particularised objects which were devised, such as observation cowls, fronts of observation posts, dummy figures and heads. All of them depended upon strict adherence in form, texture and colour to some natural object which they were intended to replace or to cover.

It is worthwhile, however, to refer to the sniper suit. Since the war of 1914-18 some enthusiasts have devised a covering of garnished netting which the unfortunate soldier, in newspaper photographs and articles, is represented as wearing. Heaven help the soldier who has to move or use a weapon when thus encased! For it cannot be insisted too often that, whatever the sniper suit is made of, the camouflage must be subordinated to the main business of observation or fighting.

The subject of machine-gun posts and similar structures also merits consideration. Every imaginable type of treatment and construction was attempted in the last war, from the comparative slight work needed for frontal obscurity to almost complete structural obscurity. The subject constitutes one of the most complicated and difficult problems in camouflage, yet it is one for which the successful solution is essential. The ideal, of course, is the post which cannot be distinguished visually, either from the ground or from the air, cannot be located in the aeroplane photograph, does not permit the flash of the firing gun to be noticed, and is not easily referable to any distinctive local object. At the same time it must offer protection against splinter and bullet. This is a big list of desiderata, but if complete fulfilment of the camouflage requirements is very difficult, much can yet be done.

First, protection against weapons. It would seem that natural protection is best; in other words, the post must be sunk. All forms of strengthening above ground only lead to complete stultification of our efforts at concealment, so that, unless the post is of such artificial strength and size as to be immune to all artillery fire save that of the heaviest siege guns, it is wiser to forgo a certain measure of protection for immunity from recognition. And when attempting the latter, the old rule must be observed; form first, texture second and colour last.

There is an eternal battle too between siting for fire and siting for camouflage requirements. But the camoufleur can, by patience and tact, usually get the two factors reconciled with each other, especially if he has had some battle experience himself; possibly even better results can be achieved when the machine-gun commander himself is fully aware of the possibilities of camouflage and has some knowledge of the technique, which demands, in the case of the M.G. commander, a small modicum of special training coupled with a normal ration of common sense.

Making Dart Boards for Bombers

Such is the story, in very brief outline, of the progress of the art of camouflage up to 1918. Throughout the Great War there had been two very distinct schools at work; the one controlled by soldiers in the field who

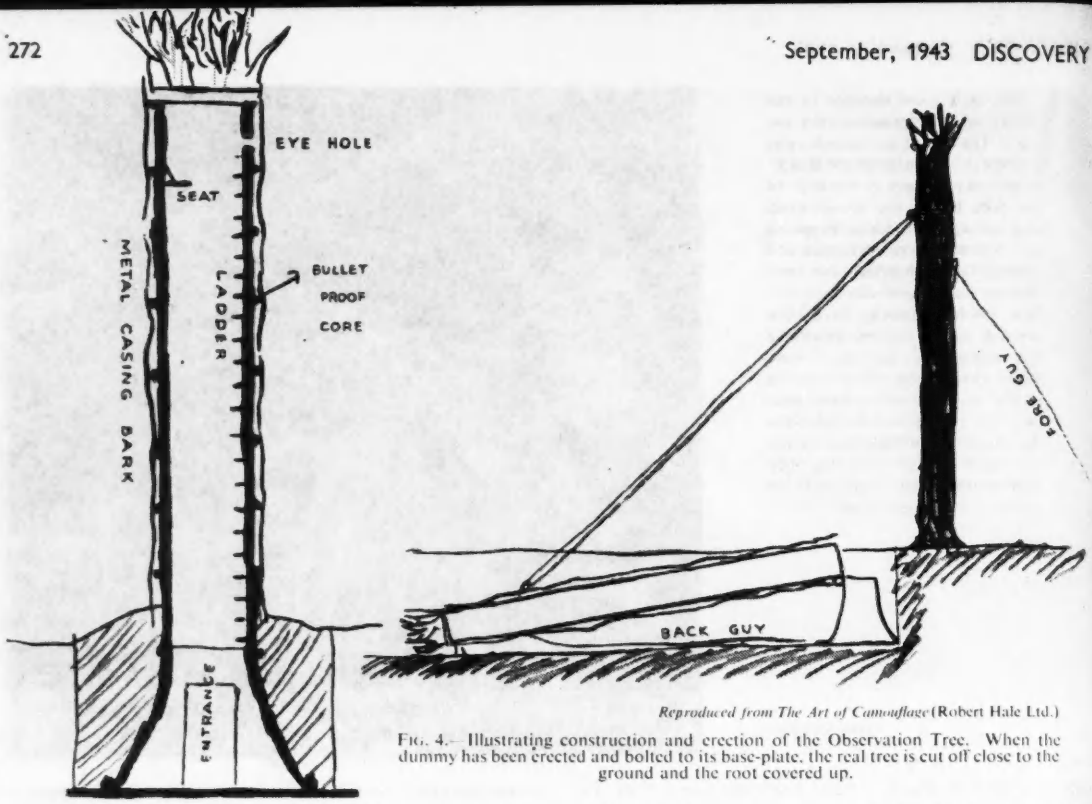

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FIG. 4.—Illustrating construction and erection of the Observation Tree. When the dummy has been erected and bolted to its base-plate, the real tree is cut off close to the ground and the root covered up.

possessed that degree of engineering, artistic, and imaginative capacity which it was clearly desirable to bring to the practice of the art. These men, trained in army organisation and tactics, were able to produce camouflage material in the prodigious quantities which any army of millions engaged in static warfare must necessarily require, to choose such inventions as could be matched to the practical actualities of the battlefield, and to discard those which could not be so accommodated, however ingenious and attractive they might appear at first sight. The other school remained in England, demonstrating in Hyde Park and on the lecture platform.

Unhampered by such mundane considerations as the suitability of any new type of camouflage device for mass production, and for transportation and easy erection by all types of users, as well as by that supremely vital and decisive factor—time—this school of theorists was able to give full vent to its unbridled enthusiasm and imagination. As its devices were not uncommonly rejected when they arrived in theatres of war, its adherents developed a doctrine of accusation against the soldier-camoufleurs in the field; they accused the latter of lack of imagination and inventive capacity. When the shackles of official secrecy were removed after the war the Hyde Park theorists were free to express themselves, and they began to put forward the most astounding claims as to the efficacy and scope of camouflage. "Strategic camouflage", for instance, made its appearance; its protagonists asserted, *inter alia*, that the chief reason for the success of the German offensive in 1918 was the wholesale camouflage of villages and roads; under its cover, they said, the enemy had been able to make their great concentration and approach to the battle unknown to our leaders in the field. They argued and "demonstrated" with enthusiasm that whole villages had been made to merge into their surroundings, while sections of roads, they claimed, had been made to disappear by camouflage. They conveniently overlooked the fact that such wholesale disappearance of features which would be outstanding in any landscape and which cannot disappear *naturally* would have defeated its own ends by calling attention to the fact that activities were on foot which it was desirable to conceal!

Out of these arguments developed the thesis that it was the artist alone who is fitted to undertake camouflage work. As a result of all this publicity the public and official mind began to accept the view that camouflage differed little from the design of theatrical scenery, and that all camouflage effects were to be obtained by the use of paints and colours. The variegated disruptive style of treatment of guns and of other relatively small objects was gaily applied to larger and still larger structures, and each extension of this type of camouflage was accepted until eventually it reached the stage when factories and complete civil installations were treated in this way. Consequently in the months before this war started, and in the early months of the war itself, the countryside became disfigured with violent cubistic designs in colour and the paint firms reaped a rich harvest as the final sacrifice of camouflage to the paint brush was made. As one critic wrote, "It has become a current joke among R.A.F. pilots that the most conspicuous buildings in the country are the ones which have been camouflaged. The effect of camouflage has been to convert relatively obscure buildings into dart-boards for bombers." Shortly,

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FIG. 5.—Showing among other things the effect of paths. For full description of faults and steps to be taken to correct, see *The Art of Camouflage*, by C. H. R. Chesney (Robert Hale Ltd.)

the faults of this phase of camouflage activity could be traced to the fact that the relative importance of form, texture and colour were observed not in that order, but in exactly the reverse!

With the opening of the new war camouflage gradually came back to the realms of experience and genuine experiment when the war began. Schemes were no longer accepted on the ground that they looked effective when painted in water colours on an aerial photograph of the factory or whatever other installation had to be concealed. The planes were up, and the effectiveness of camouflage designs soon came to be judged by the only criterion that matters—their ability to defy detection when the areas containing the camouflaged installations are searched in the same way that the enemy would do when attempting to detect military targets.

Camouflaging the Man

Let us consider some of the camouflage developments this war has brought. First, camouflage as it concerns the soldier himself. A covering of some rough material for the steel helmet is now a standard piece of equipment. This is totally correct. In battle the man can do nothing towards concealing himself when moving except to place something between himself and the enemy, i.e. to move under cover. But when stationary he endeavours instinctively to present as small and inconspicuous a target as he can. Yet a certain portion of his head he must always present, and the helmet is consequently the most important portion of his body from the camouflage point of view. It is clear therefore that the smooth shiny surface of the helmet is thoroughly dangerous. A cover of canvas or of net that can be garnished stops the reflection, but one wonders whether it might not be possible to treat the metal of the helmet itself so as to give it a rough, non-reflecting surface, so as to obviate the addition of a perishable cover.

Many modern camouflage booklets discuss at length the rules of behaviour which the soldier must adopt in order to achieve the maximum degree of concealment, but this point usually comes down to studying his surroundings and accommodating himself thereto; in other words, to plain field-craft and hunting-craft. The uniform of the British soldier to-day seems to be a combination of utility and camouflage as near perfect as it is possible to conceive. In colour perhaps there exists a shadow of doubt: khaki is undoubtedly the best tone against close visual observation, at which distance field-craft is of greater importance than any fine shading of colour. But at the greater distances at which rifle, machine-gun, mortar and artillery fire actuate the khaki colour is probably not so effective as a hybrid colour like khaki-grey or a dirty blue-grey. (It is interesting to note in this respect that in recent weeks slate-grey uniforms for officers have been adopted by the U.S. Navy Department in replacement of khaki; according to the official Washington statement, the change in colour has been made after months of experiment to find "a colour which would be less conspicious than the present khaki".) Pure khaki at such distances tends to develop too deep a tone and will only match in with the deeper shadows. It is clear from modern manuals that the necessity for bringing home the importance of camouflage discipline is stressed by the

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FIG. 6.—Illustrating difference between matt and glossy surfaces of exactly the same colour.

authorities; in other words by resolving camouflage for the ordinary soldier into instruction in and obedience to the rules of field-craft, camouflage is relegated, as it should be relegated, to the realm of plain thought and common sense.

It is a mistaken notion that camouflage is the exclusive province of the artist, and I believe that the War Office was right when, after the fall of France, it decided that camouflage must cease to be a mystery superimposed upon the ordinary officer and the ordinary man by specialists and must become the concern of every unit, which would then be responsible for its own camouflage though still able to obtain advice from the specialist camouflage officers.

Problem of Vehicles and Guns

Camouflage of vehicles, both transport and armoured fighting, is important. Shadow, revealing as it does the *form* of the vehicle, is the prime consideration. Paint your lorry what colour tones you like and in what design you like, provided all are "dirty" tones. Let the vehicle remain as dirty as is consistent with mechanical efficiency and it will have the best coloration for concealment. Obviously if operating in dusty light-toned surroundings, such as the African desert, the dust should be on the vehicle too; if transport has to use tarred roads or green fields dirty deep tones will be best. Shadow is the great tell-tale, and here discipline comes in. That shadow has got to be absorbed into the landscape, and by natural means. Camouflage of moving vehicles is well nigh impossible, but when they are stationary they should be parked so that shadow is merged with the tones of hedges, woods, ditches and other dark natural features. It is common practice for vehicles to carry garnished nets, similar to those used for artillery. Nine times out of ten this can serve little purpose except to eliminate or modify shadow—with problematical success—when the vehicle is not moving. I rather think that such netting would be put to better use if it were passed over to a machine-gun post or other party which is fighting in the neighbourhood and finds itself in sore need of some netting with which to camouflage itself.

With artillery camouflage, there has been a great modification in the use of nets as compared with the last war. In 1914-18 the difficulty lay in defeating the eye of the camera; in this war of greater movement more danger derives from the eyes of the man in the observation post,

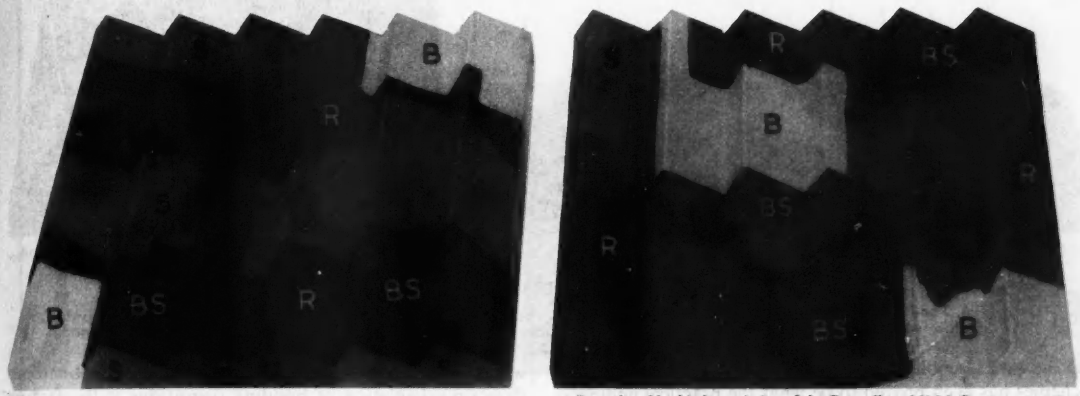

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FIG. 7.—Illustrating imitative and disruptive patterns on a factory in a town. All colours are normal in the surroundings: the shapes are typical of house tops, shadows and irregular patches of grass and ground.

R.—Red Tiles. S.—Slates. G.—Grass. B.—Buff ground. BS.—Black Shadows.

or of the observer in the reconnaissance plane, and in both cases distance will offer obstacles to detection. Therefore the meticulous elimination of shadow which was essential in camouflaging a gun position in the last war is no longer so necessary, and more or less careless draping of the netting should suffice, except when static conditions again arise. When these do occur, the same care in application that was characteristic of the last war will again have to be taken.

From these considerations of camouflage for individual soldiers, weapons and vehicles, we pass to those of concerted action; the camouflage of small units such as the platoon and section, and passing through the larger company, battalion, etc., to that of the army formation. Naturally the platoon that is made up of men who know the elements of field-craft and self-concealment will act in cohesive action on the same principles; the care and guile of the platoon can be no higher than that of the individuals it contains.

"Kill, or be Killed."

What is the sum total of all these attempts at concealment? Primarily to avoid being killed, but ultimately to gain ascendancy over the enemy by killing (or capturing) and not being killed (or captured). "Kill or be killed" was the title of an official film about snipers; it could equally well be used for a camouflage film. One's advantage over the enemy may be obtained by other factors beside the concealment of form, or intention, or strength. It may be attained by superior protection or by superior weapons. But between armies of approximately equal calibre it is finally the factor of surprise that decides the issue; the attack from the unsuspected quarter or in unsuspected strength. This aim can be achieved by one means alone—by concealment of intention or of movement.

There is no soldier in the army, no individual of so small account, that he can afford to forget for one moment this effect which the strategists endeavour to create. By his contribution and understanding the soldier carries out the project, and it cannot be too strongly stressed that all the training a soldier receives in camouflage should lead ultimately to an appreciation by him of its importance to the success of any tactical or strategical aim.

In the last war, with defence supreme in its cobweb of barbed wire and machine-gun, it seemed for a time impossible to effect surprise. It was not until the tank arrived on the scene that the barbed wire could be negotiated without that preliminary artillery bombardment which gave the enemy time to make the necessary defensive preparations. At first the full possibilities that the tank offered were not realised. But when they were, surprise came into its own again, as was instanced at Cambrai and on 8 August, 1918, when the "Cambrai Key" was reapplied. Let it not be forgotten, however, that it was camouflage carried out by the individual soldier, as well as by those in higher authority, which was used to such great effect. In every detail of the approach and the attack itself, no object or action lacked the attention necessary to ensure that it was not detected by the enemy.

In this war battle action has been transformed in other ways besides that of freedom of movement, so that the opportunity to deal the surprise card is ever present. Camouflage of object still remains and will always remain a potent contributing factor. The substitution of dummy tanks for the armoured fighting vehicles of the Tenth Corps after they had moved from their position, 50 miles behind the El Alamein battle area, is a good example of what can be achieved; in this instance, attack—feint and real—followed the gaining of the factor of surprise by camouflage. So also in the Battle of Tunisia, the perfect exposition of feint, disposition of strength and thrust in order to deceive and destroy.

Camouflaging Civil Installations.

It is perhaps in the field of civil-installation camouflage that there has been the greatest change of heart during the present war. The daubing of such intractable structures

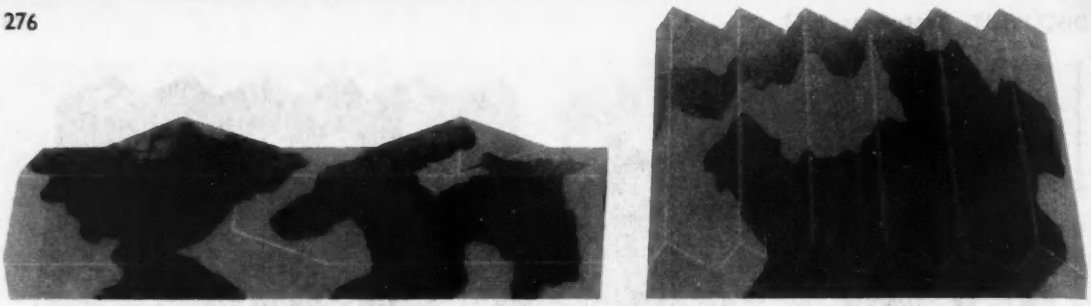

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FIG. 8.—Illustrating grass and earth pattern which is also disruptive.

In Figs. 6, 7 and 8, which are taken from the A.R.P. Handbook entitled *Camouflage of Large Installations*, no shadow is shown. It is shadow which would reveal buildings camouflaged in this way by paint, by reason of its straightness and squareness.

as oil tanks, cooling towers, etc., with startling colour schemes has been proved to be what the practical engineer and architect have always predicted. Modern practice has developed uniform inconspicuous toning, which is the best form of coloration for such installations, and war-time experience has shown that no type of surface treatment can effect, by itself, any serious concealment. For one thing, bombing in its extent and promiscuity neutralises in no small degree the camouflage of large installations. Factories which were standing long before the war started can be located by reference to landmarks in their vicinity, and no matter how one alters the appearance of such factories they can still be found and destroyed. The national policy of dispersion is manifestly the correct answer to this problem. In the case of smaller installations, however, much improvement in the manner of camouflage treatment has been made, chiefly in the direction of siting, and design of lay-out and form rather than of colour. It is clear that the engineer and the architect rather than the artist have been the agents mainly responsible for such progress, and an immense amount of labour and time would have been saved if the work had been entrusted to them in the first place.

There is still a great field for improvement in this direction analogous to the camouflage discipline which is taught in the army. Too little attention to the approaches to the installations, to conspicuous yards and areas within it, and to disturbance of ground surface during construction (when new factories have been built during war years). It is of little value to provide perfect camouflage on completion of building operations if the factory has been given violent advertisement during construction. More consideration should be given to the opportunities for "architectural camouflage"; the tell-tale shape and lay-out of oil storage tanks and installations, etc., for instance, demand the attention of the engineer and the architect so that they shall contain the possibilities of being camouflaged later, instead of, as at present, offering no possibility of proper elimination. The same remarks apply to the construction of aerodromes, gun sites, etc.

In the field of concrete, perhaps, lies the greatest prospect for revolutionary advances in camouflage by structural design. No success is possible if the concrete approaches and areas remain as beacons to the enemy airmen. Is it impossible to provide permanent coloration of the concrete in the few dull tones required for camouflage? When this can be done artificial shadows, indicating non-existent features, can be provided, while natural shadow—the great tell-tale—can be so adapted as to effect, with the artificial representations referred to, complete falsification of the appearance of the target itself.

To sum up, the future of the camouflage of static objects, particularly those of larger dimensions, lies with the architect and the engineer. With its possibilities fully explored and due consideration given to them in the original design, a great step forward will have been made. The degree of success that will then be achieved will come, I venture to think, as a great surprise to many.

Raw Materials for Synthetic Rubber

IN a recent number of the American Chemical Society publication *Chemical and Engineering News*, Walter J. Murphy, the editor, gives an excellent description of a visit he and other pressmen paid recently to a U.S. Government synthetic rubber plant at Institute, West Virginia. This plant is jointly operated for the Government by the Carbide & Carbon Chemicals Corporation and the U.S. Rubber Company and is designed to produce 90,000 tons a year of "Buna S", a copolymer of butadiene and styrene. The production of this plant would be sufficient to make 16,000,000 passenger car tyres a year and is the equivalent output of a 270,000 acre rubber plantation.

Butadiene is made from alcohol derived from the fermentation of corn and 197,000 gallons of alcohol per day are consumed. Alcohol can also be produced synthetically from petroleum products and this method is being used in some other U.S. butadiene plants. The raw materials used for the manufacture of styrene are benzine, obtained from coal tar, and ethylene, which is derived from coal gas, petroleum gas or alcohol. In addition to these basic raw materials the plant at Institute consumes 120,000 gallons of water a minute, 14,400 kilowatts of electricity, and 7,700 tons of coal a week. Water treatment consumes in a year 91,000 lbs. of chlorine, 690,000 lbs. of alum, 254,000 lbs. of soda ash and 25,500 lbs. of sodium hexametaphosphate. Over 40,000 lbs. of soap a day are used in making the emulsion before the copolymerisation reaction, while the coagulation of the Buna S formed in this reaction uses 70,000 tons of rock-salt a day as well as large quantities of sulphuric acid and caustic soda. In addition various unspecified catalysts, reaction inhibitors and rubber antioxidant are consumed by the plant. The control laboratory, 50% of whose staff are women, tests 1,200 to 1,600 samples per day.

These figures for one Buna S plant give some idea of the colossal productive achievement of American science and technology, which is now stated to be well on the way towards meeting the demand for 800,000 tons of synthetic rubber per year.

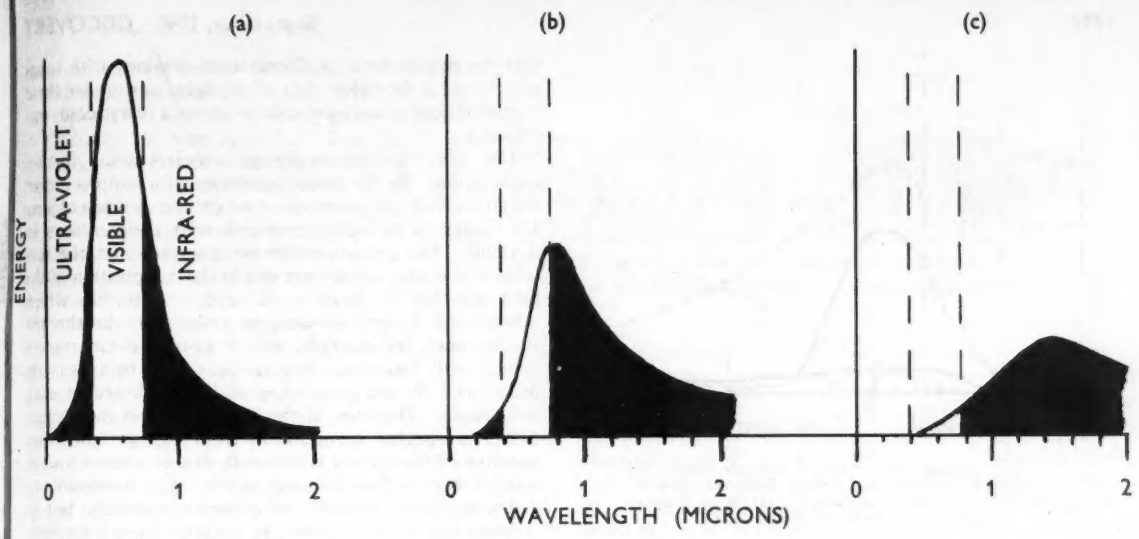


FIG. 1.—Energy distribution of radiation emitted by "black bodies" at various temperatures: (*a*) 6,200°C., (*b*) 3,700°C. and (*c*) 1700°C. (1 micron = 10,000 A.U. = ·0001 centimeters.)

Fluorescent Lighting

C. G. A. HILL, A.R.C.Sc., B.Sc.

PROGRESS in science has for many years followed a course of specialisation, each advance leading the worker farther into the intricacies of his own branch of study and isolating him from his fellows. This isolation was enhanced by the tendency for each branch of science to develop its own private language and method of thought, sometimes more or less unintelligible to workers in other branches. Of recent years however a change has come about, and the most promising advances have been the result of co-operation between specialists of different kinds. The discovery of fluorescent lighting is but one of the many examples of co-operative progress which have occurred in the last ten years. Those who are chiefly responsible for its development are the chemist, the physicist and, in the background perhaps but equally essentially, the mathematician.

Let us first briefly consider man's previous efforts at artificial lighting, their merits and shortcomings, and a few of their general characteristics.

Ignoring the practice of certain American Indians who are said to have used captive fire-flies to illuminate their teepees, we find that all the early artificial illuminants were what the physicist calls "temperature radiators", *i.e.*, the light was produced by heating something to a high temperature. Now the sun itself falls into the class of temperature radiators, so that the difference between sunlight and candlelight is one of degree rather than of kind. The sun emits radiation characteristic of a black body at a temperature of 6200° C, while the radiation from a candle is due to carbon particles in the flame at a temperature of about 1100° C. This radiation covers a broad band of wavelengths, including both the ultra-violet and the infra-red besides visible light, the proportions of each depending on the temperature as shown in Fig. 1, in which the area under each part of the curve represents the total energy radiated at the respective wavelengths. Until the invention of the incandescent gas mantle the only improvements in light sources were effected by increasing the temperature of the light-emitting body, in order to increase the proportion of visible radiation. Such progress was limited by the impracticability of attaining in a household lamp temperatures greater than 1300° C.

The incandescent gas mantle, which was the next step forward, made use of certain substances, known as "selective radiators", which emit radiation when heated that differs in the distribution of energy among the wavelengths from that of a black body at the same temperature. Some of these substances—a mixture of ceria and thoria being the most effective—emit a greater proportion of visible light than a black body at the same temperature, but nevertheless a large amount of invisible radiation is still present (see Fig. 2). The result is an increase in the efficiency of the light source, accompanied by a change in its colour. In the case of the gas mantle a greenish tinge was introduced.

The development of the electric incandescent lamp followed much the same course. First, using a carbon filament, the running temperature was raised as high as possible, and then a search was made for other materials which were either selective radiators of the same type as the ceria-thoria mixture or could be run at high temperatures without evaporating and causing failure of the lamp. The

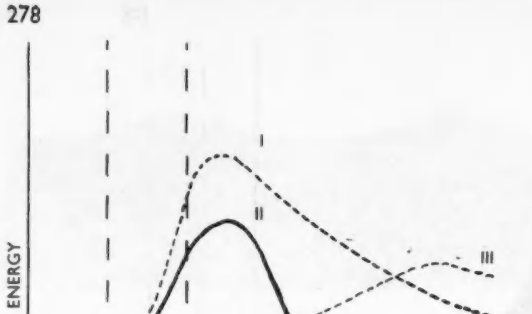


FIG. 2.—Energy distribution of radiation emitted by "selective radiators". I. Black body at 2500°C. II. Tungsten filament at 2500°C. III. Black body at 1350 C. IV. Ceria-thoria mixture at 1350°C.

material finally chosen and used universally to-day was tungsten. The energy distribution curve throughout the spectrum for a gas-filled 75-watt tungsten lamp running at a temperature of about 2500°C is shown in Fig. 2.

The Incandescent Tungsten Lamp

As the immediate predecessor of fluorescent lighting we must consider in greater detail the important characteristics of the tungsten filament lamp. There are three main factors which must be taken into account when considering any light source. They are (*a*) the efficiency, (*b*) the colour, (*c*) the colour rendering. The first two of these can be measured and expressed numerically, but the colour rendering can only be assessed qualitatively.

The efficiency of the lamp is usually expressed in lumens per watt of input energy. The lumen is the unit of quantity of light and is defined in terms of the amount of light emitted by a standard lamp. The tungsten lamp has an efficiency of about 12 lumens watt.

The eye is much more sensitive to wavelengths in the centre of the spectrum than to those at either end. That is to say, of equal amounts of energy radiated as dark blue, yellow-green and deep red, the yellow-green light appears by far the brightest. The curve showing the change in eye sensitivity with wavelength is given in Fig. 3. The theoretical maximum efficiency for a lamp radiating all its energy at the wavelength of maximum visibility is 625 lumens watt, while that for a lamp radiating equal quantities of energy at all the visible wavelengths only is about 200 lumens watt. The extremely low figure for the tungsten lamp is due to the large amount of heat which is radiated as infra-red rays, together with that which is lost in heating up the bulb and fittings. The infra-red radiation is a considerable disadvantage in a light source since it has the effect of heating up the objects which are illuminated.

The colour of a tungsten lamp is accepted as "white" although in fact it is more yellow than daylight; but this is only unpleasantly obvious when the two are seen simultaneously. It is a curious fact that nearly all the lamp shades in general use tend to accentuate this difference rather than eliminate it. This is probably due to the fact that the general level of illumination obtained with tungsten lamps is far below that of daylight, and under these circumstances a daylight colour gives a very cold impression.

The term "colour rendering" requires some further explanation. By the colour rendering of a lamp is meant the amount of change in colour which occurs when objects are viewed in its light, compared with their colours in daylight. The colours which we associate with the surfaces of everyday objects are due to the composition of the light reflected by them to our eyes. A surface which reflects the longer wavelengths only and absorbs the shorter ones, for example, will, in normal circumstances appear red: the actual hue in each case being exactly determined by the proportion of light reflected at each wavelength. However, if the light falling on the surface differs in spectral composition from daylight the composition of the reflected light will also be altered and in general there will be a change in hue. It is impossible to define the colour rendering of a lamp numerically, but an estimate can be made from the spectral energy distribution curve of the lamp. The ideal case is that of a lamp radiating equally at all wavelengths in the visible region of the spectrum, since this is practically the composition of daylight. A glance at Fig. 2 shows that this is by no means the case for the tungsten lamp, there being much more energy radiated at the red end of the spectrum than at the blue. The effect of this on the colours of objects is considerable, but, perhaps because for generations man has used artificial light of a similar character (*i.e.* temperature radiation), he tends to accept these colour changes without question, and often without noticing them except in special circumstances. These changes are most pronounced in the case of dark blues, and every needle-woman is familiar with the impossibility of matching threads of these colours in the present artificial light.

To sum up then, the tungsten filament lamp is grossly inefficient as a converter of electrical energy into light, but has acceptable colour and colour rendering for normal household illumination.

Various attempts at improving these three factors have

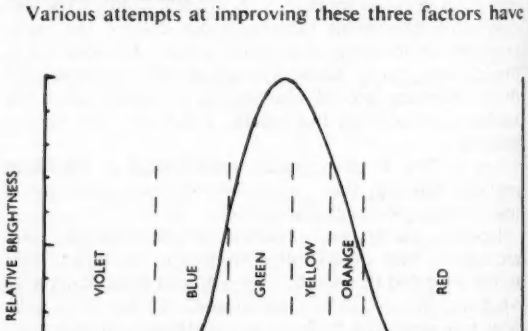
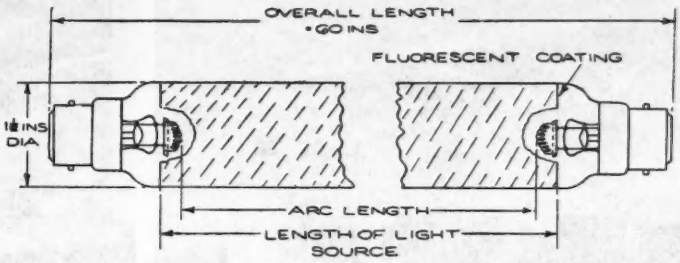


FIG. 3.—Variation in sensitivity of the eye throughout the visible spectrum.

been devised, but in no case hitherto has it been possible to produce a lamp in which all three are better; every gain in efficiency has been accompanied by a falling off in colour rendering, while the latter has only been improved at the expense of the efficiency. Naturally the economic background to the problem of efficiency has been a powerful incentive to research, and it is in this field that most advances have been made. These have all been developments of the gas discharge lamp, previously used for many advertising purposes in the familiar form of neon tubing.

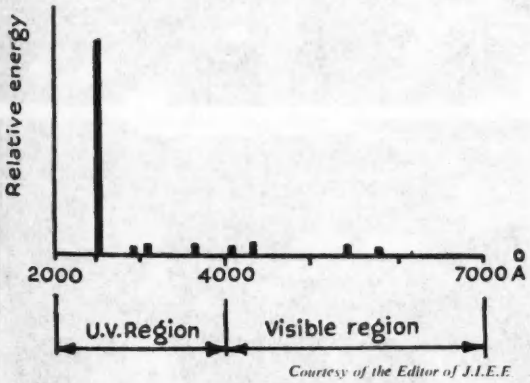


Courtesy of Editor of J.R.S.A.

FIG. 5.—Constructional details of 5 ft. 80-watt fluorescent tube.

In its simplest form the gas discharge lamp consists of a glass envelope containing two electrodes and filled with a controlled quantity of a particular gas. When a current flows through the lamp electrons bombard the atoms of the gas causing it to emit radiation. Unlike the radiation emitted by a hot body, however, it is only emitted with certain particular wavelengths, which may be in the visible, the ultra-violet, or the infra-red. When analysed by a prism the light from a discharge lamp gives rise to a series of "spectral lines" of different wavelengths characteristic of the gas in the lamp, in the same way that metals in an electric arc give rise to their characteristic spectra. (See Twyman, DISCOVERY IV, 16, 1943.)

For lighting purposes two main types of discharge lamp have been developed, the one using sodium vapour and the other mercury as the gas in the tube. These metals were chosen because the greater part of the total energy radiated by their discharges is emitted at wavelengths in the visible range. In the case of sodium nearly all the energy is radiated at about 5900 Angstrom Units (A.U.) in the yellow, which as we have seen (Fig. 3), is fairly near the maximum of the eye sensitivity curve. We can therefore expect a high efficiency from such a lamp. The mercury discharge contains a strong line at 5461 A.U. and a number of others in the visible and ultra-violet, as shown in Fig. 4. With these lamps efficiencies of about 50 lumens watt have been obtained for lower wattages (100-500) and much higher values for the extremely powerful sources used in searchlights and lighthouses. Neither type however could possibly be used for domestic or office lighting owing to their extremely poor colour and colour rendering. The disagreeable effects on the complexion caused by sodium and mercury vapour street lights are too well known to need further comment, and the explanation lies in the discontinuous—or line—spectrum which is the basis of their high efficiency. For example, neither lamp radiates any red light so that all red objects appear brown, while purples appear blue. Consequently these lamps are only used where colour is of secondary importance: *i.e.* in street lighting and in certain specialized industrial cases.



Courtesy of the Editor of J.I.E.E

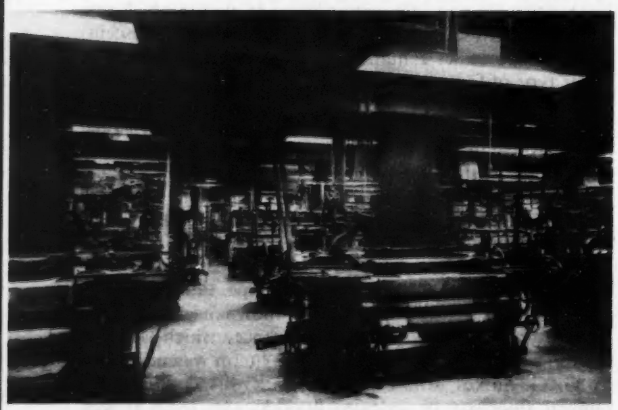
FIG. 4.—Energy distribution of radiation from a low pressure mercury discharge.

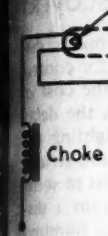
Principles of the Fluorescent Lamp

We are now in a position to turn to the tubular fluorescent lamp which, in its present form, has gone a long way towards combining the efficiency of the discharge lamp with colour and colour rendering properties which are better than those of the tungsten lamp. The fluorescent lamp also possesses a number of advantages unknown to either type of forerunner.

The phenomena of the luminescence of solids have been known for many centuries, but it was not until the middle of the last century that the properties of these bodies were investigated with any thoroughness. Certain solids have the property of absorbing radiation over one range of wavelengths and at the same time emitting radiation over another range. Many of them are also excited to emission by X-rays, cathode-rays, etc. Most of them continue to emit with decreasing intensity for some time after the excitation has ceased, and this is known as phosphorescence, as distinct from fluorescence which is the emission during excitation. The latter term was proposed by G. G. Stokes, whose pioneer work was done on the mineral fluorspar or calcium fluoride. In 1852 Stokes formulated the first "law" of luminescence, which states that "it is impossible to obtain fluorescence radiation of shorter wavelength than the exciting radiation".

The significance of this law in our story appears when we compare the emission curve for a tungsten lamp (Fig. 2) with the spectrum of a mercury discharge (Fig. 4). While the bulk of the radiation from the tungsten lamp lies in the infra-red on the long wavelength side of the visible region, we see that the mercury emits at a number of wavelengths in the ultra-violet. If therefore we are to use fluorescent materials to convert some of the wasted invisible radiation into useful visible light it is to the discharge lamp that we must turn. The first practical





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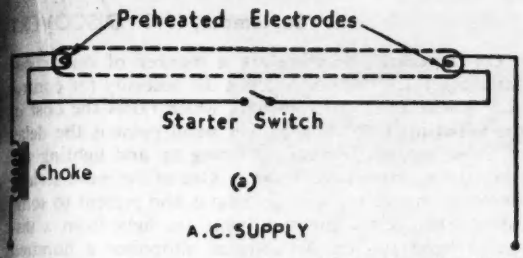


Courtesy of the Editor J.I.E.E

FIG. 7.—Circuit for operation of fluorescent lamp on a.c. mains.

attempt at using luminescent materials in this way was patented in 1932, and since that date numerous different methods have been tried out, culminating in 1939 in the appearance of the mains voltage fluorescent tube.

The tubular fluorescent lamp, which for the duration of the war is only being made in an 80-watt size, consists of a glass tube 5 feet long and 1½ inches in diameter, capped at each end with an ordinary bayonet cap similar to that of a tungsten lamp. The discharge is in mercury vapour at low pressure between two specially constructed electrodes, and almost all the light comes from the fluorescent powder which is coated on the inside of the tube (see Fig. 5).

Mercury vapour was chosen because its spectrum contains a strong line in the ultra-violet at 2537 A.U. The distribution of the total energy of a discharge among the various wavelengths at which it is emitted can be altered by varying such conditions as the pressure of the gas, or the current passing through the tube. It was found that when the mercury vapour pressure was about ·009 mm. or $\frac{1}{5400}$ of the normal atmospheric pressure almost all the energy of the discharge was radiated at this wavelength.

For a current to flow through the tube, electrons must be removed from the negative electrode. The removal of an electron from a clean metal surface is a drastic and violent procedure, requiring a very high voltage, and the life of an electrode under such conditions is very short. These difficulties were overcome by using electrodes consisting of a tight coil of tungsten wire coated with barium or strontium oxide. Such a coil, when heated, emits electrons very readily, in the same way that the cathode of a modern radio valve emits electrons when hot. In the lamp a small current is passed through the coils initially to raise them to red heat, and subsequently the discharge itself keeps them hot.

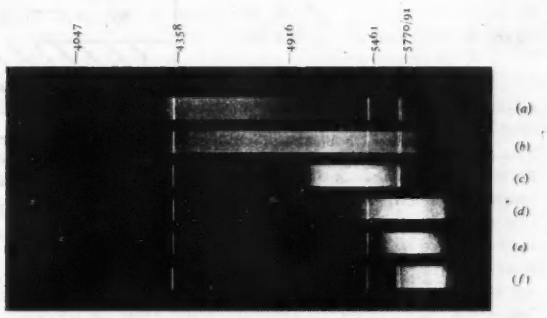
Once the discharge has been struck, if left to itself, the current would increase very rapidly owing to bombardment of the mercury atoms by the electrons producing more free electrons, which in turn would bombard more atoms, and so on—the vicious spiral rising until the lamp bursts or all the fuses blow! To prevent this on A.C. circuits, a choke is used. This is a device consisting of a number of coils wound on an iron core, which will only allow a fixed current to pass through it, even if the leads are short-circuited on the other side. On D.C. circuits, a resistance in series with the lamp has to be used. This is a wasteful method, while the choke consumes hardly any energy.

One further piece of equipment must be mentioned before we consider the fluorescent powders, and that is the starter switch. This is an automatic device for supplying the electrodes with their initial heating current and then starting the discharge by applying a sudden voltage surge across the ends of the tube. The circuit used is shown diagrammatically in Fig. 7. Various types of switch have been developed but the basic principle of all of them is the use of a bi-metallic strip which bends when heated. One or more such strips, enclosed in a small glass bulb, are used as contacts. The heat may be supplied by a small coil close to one of the strips, or by a glow discharge in a rarefied gas between the strips themselves.

Finally we come to the fluorescent powders. The ideal powder for these lamps would absorb all the ultra-violet emitted by the mercury discharge and emit a continuous spectrum in the visible with the same spectral distribution as daylight. Since this ideal has not yet been found, a number of compromises have been made. The first necessity, that of the absorption of ultra-violet at 2537 A.U., has been fulfilled as a result of extensive chemical research, and there are three groups of powders which absorb in this region. They are (*a*) silicates, (*b*) tungstates, and (*c*) borates and phosphates. No one of these powders however emits equally at all visible wavelengths, and so a mixture of powders is used in the lamps whose total emission approximates to this ideal. The actual colour emitted by each powder depends very much on the details of the preparation as well as the composition. Briefly the preparation consists in first purifying the oxides of the elements involved, then adding a small but carefully regulated amount of a metallic impurity (usually manganese), and finally heating to a high temperature. However the proportion of the constituents, the time of heating, and the rate of cooling all influence the colour of the light emitted by the powder and must be carefully controlled. A list of the powders in use is given in the above table, and their spectral energy distributions are shown in Fig. 8.

TABLE I

Powder	*Fluorescent Colour*
Zinc Beryllium Silicate	Golden yellow, orange or salmon pink.
Zinc Silicate.	Green.
Calcium, Magnesium } Tungstate	Pale blue or green.
Cadium Borate, Cadmin Chlorophaphate }	Red.



Courtesy of the Editor of J.R.S.A.

FIG. 8.—Spectra of fluorescent powders used for fluorescent discharge lamps. (Wavelengths in Angstrom units.)

← FIG. 6.—Fluorescent lighting in commerce and industry. Photographs by courtesy of the General Electric Company

It can be seen from the curves of Fig. 8 that almost the whole of the visible range can be covered by a mixture of these powders, with the exception of the very deep red.

Fluorescent Lamp Performance

Taking the three main factors in lamp performance in turn we come first to the efficiency. The published figure for the present lamp is 35 lumens/watt, which compares favourably with other discharge lamps of the same power and is considerably better than the tungsten lamp. In Fig. 9 the ways in which the energy of a tungsten lamp and a fluorescent lamp of the same wattage is dissipated, are compared. It will be seen that although much of the energy is still converted into heat by the fluorescent lamp the proportion which is radiated as infra-red rays is much less. Consequently the heating effect is localized at the lamp fitting and does not heat up the objects illuminated. The normal running temperature of the tube wall is 45°C as compared with 150°C to 200°C for a tungsten lamp.

The colour of the lamp can be varied over a wide range by altering the proportions of the powders in the coating. At present, however, a daylight colour is the only one available in this country, although three different whites and five coloured lamps are marketed in America.

The colour rendering is a vast improvement on that of the tungsten lamp, blues and greens being shown up as vividly as in daylight. The slight deficiency in the deep red is quite unnoticeable in ordinary circumstances and only becomes evident when making accurate colour matches.

Other advantages of these lamps include the absence of glare due to the low brightness of the lamp surface. It is possible to look directly at the lamp without discomfort since the light is being emitted from the whole surface. The large emitting surface also removes all sharp shadows, giving an even diffuse lighting similar to that obtained from a north skylight. Although this is an advantage in many respects, it appears that a small percentage of people have difficulty in judging distances under such lighting, probably owing to some defect in their visual mechanisms.

On the debit side there are a number of minor disadvantages, the chief of which is the necessity for control gear (choke and starter switch), which raises the cost of the initial installation. Another small point is the delay of a few seconds between switching on and lighting up, while the electrodes are heating. One of the more serious defects of the plain discharge lamp is also present to some extent. Unlike the tungsten lamp, the light from a discharge lamp run on A.C. ceases altogether a hundred times a second as the 50 cycle mains voltage passes through the zero value. This gives rise to a stroboscopic effect which results in a flicker appearing on fast moving objects. A spinning spoked wheel, for example, may appear stationary or even turning backwards, in the same way that car wheels or tank tracks on the cinema screen. In the fluorescent lamp this is to some extent alleviated by the phosphorescence of the powder, which tends to bridge the gap while the excitation ceases, and it can be almost completely eliminated by running two lamps side by side using a special circuit which causes the voltage on one lamp to be at its maximum while that on the other is zero.

Future Development

It can be seen from Fig. 9 that the fluorescent lamp is by no means a perfect converter of electrical energy into light, and there is room for improvement in a number of directions. In the immediate future we may expect to see the development of fluorescent powders of higher efficiency, emitting over a wider spectral range and phosphorescing more strongly. For display purposes a wide range of colours will probably be developed. This will also present a valuable tool to the architect. On the other hand, gases besides mercury vapour may be found which provide better excitation; preliminary experiments with neon have already been made.

The full potentialities of these lamps in the home, the office and the factory are far from being realized as yet, but there is no doubt that within a few years of the end of the war the fluorescent lamp will be as familiar and probably as cheap to buy as the tungsten lamp is to-day.

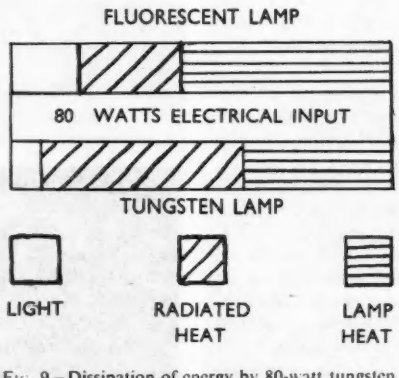


FIG. 9 – Dissipation of energy by 80-watt tungsten and fluorescent lamps.

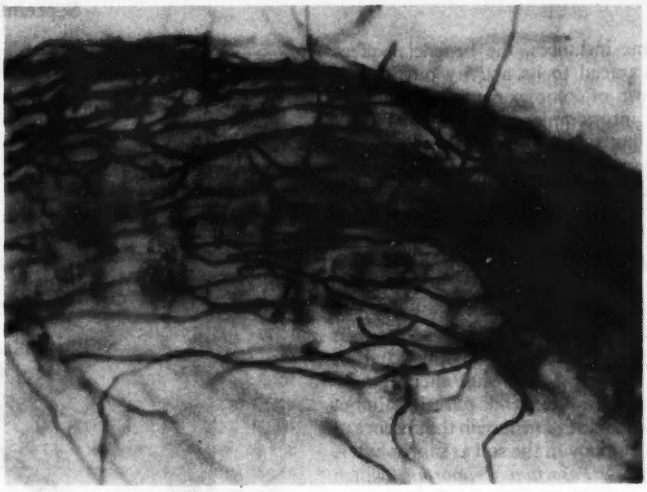


FIG. 1.—Photomicrograph showing dark-coloured threads of the take-all fungus growing along a wheat root.

Soil Fungi and Crop Production

S. D. GARRETT, M.A., D.I.C.

WHEN a plant dies, its roots are soon invaded by a variety of soil micro-organisms. Prominent amongst the early invaders of the root tissues are species of fungi, the threads of which grow rapidly from cell to cell. The soil fungi play a particularly important part in the initial decomposition of the plant skeleton, by virtue of their efficiency as cellulose decomposers. When the hyphae or individual threads of fungus have exhausted the supply of decomposable carbohydrate in their immediate vicinity, they die. The dead hyphae are then in turn decomposed by various species of soil bacteria. When supplies of available carbohydrate in the dead plant tissues have become nearly exhausted, the nitrogen and phosphorus locked up in the cells of the decomposing micro-organisms become mineralised through the activity of yet other micro-organisms, and are set free in the soil as nitrates and phosphates. Soil fungi thus form the first link of the living chain along which the organic nitrogen and phosphorus of dead plant tissues becomes converted back into nitrates and phosphates, suitable for absorption once more as nutrients by green plants.

Not all activities of soil fungi are so beneficial to the growth of green plants. It may be supposed that at some stage in the evolution of soil fungi from primeval forms living on decaying organic matter, certain individuals acquired the ability to penetrate the living underground parts of green plants. In so doing, they were able to exploit a virgin substrate with that initial freedom from competition and interference which is the prerogative of pioneers. Amongst green plants, a similar advantage is possessed by pioneer colonisers of such habitats as shingle banks, sand dunes, and rock surfaces, which are unsuitable for the growth of most species.

Mycorrhizal Fungi

This evolution of the parasitic habit has progressed so far in certain types of soil fungi as to become a symbiosis with the host plant, the harmony of which is upset only in an abnormal environment. Such symbiotic fungi are known as mycorrhizal fungi. Certain types (*ectophytes*) form characteristic mantles of fungus threads around the roots of their host plants, and are thought to supersede the root hairs in the absorption of nutrients from the soil. Many species of deciduous tree, and the majority of conifers, are regularly associated with specific ectophytic mycorrhizal fungi. This association is so regular as to suggest that it is obligate for the host plant. Foresters have frequently found it impossible to establish exotic conifers in the absence of the appropriate mycorrhizal fungus. According to a survey made by the Imperial Forestry Institute, and summarised by M. C. Rayner, there is widespread empirical use of soil or humus inocula taken from old stands of a particular coniferous species to assist in the establishment of the tree on new sites.

Other mycorrhizal fungi (*endophytes*) develop no fungus mantle external to the host plant, and are found only within its tissues. Most species of orchids are as regularly associated with such fungi as are coniferous trees with ectophytic forms. In the absence of the appropriate endophyte, it is difficult to secure seedling germination and establishment in many species of orchids, so much so that orchid growers have found it necessary to ensure infection of the orchid seed by the mycorrhizal fungus, either by inoculation with pure cultures or by indirect methods. Opinion is divided amongst botanists as to the reasons for the orchid's apparent dependence upon infection by its

fungus parasite. In some instances, the beneficial effect of the fungus has been traced to its activity outside the host, in the breaking-down of complex organic substances in the rooting medium into simpler ones assimilable by the seedling. The view that such fungi may fix substantial amounts of atmospheric nitrogen, as do the nodule bacteria of legumes, has not been sustained by experiment, but it has recently been suggested that the fungus may provide its host with growth factors.

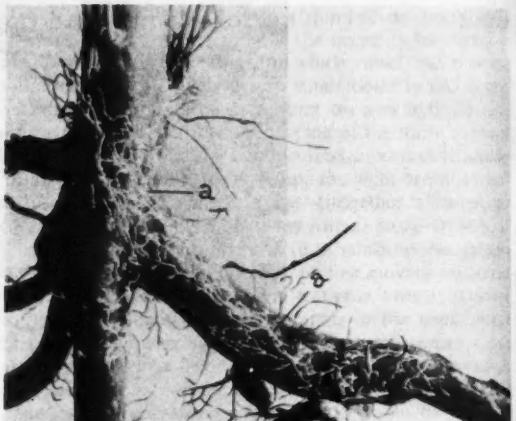
Life of Parasitic Fungi

It is impossible to draw a sharp dividing line between saprophytic fungi living on decaying organic matter, which are beneficial to crop growth through their activity in breaking down plant residues, and parasitic fungi, which rob their host plants. Some parasites, in the absence of host plants, can exist indefinitely in the soil as saprophytes; such a one is the fungus *Fusarium culmorum*, which sometimes causes poor germination in cereal crops and empty ears at harvest, but yet fulfills a useful function in the economy of crop growth through its great activity in stubble decomposition after harvest.

Whilst admitting, therefore, that a fungus can alternately exist as a saprophyte harmless or even beneficial to crop growth, and as a parasite which is the reverse, it can yet be said that all the soil-borne diseases of major economic importance are caused by highly specialised parasites. Specialisation has increased the degree of parasitic efficiency in such fungi, but has so reduced their power to compete with saprophytic micro-organisms that their survival in the soil is limited to a mere persistence in the dead tissues of their host plants. In the continued absence of suitable host plants, therefore, the numbers of such a parasite in the soil must steadily dwindle. The more specialised the parasite, the fewer the species of plant that it can infect, and so the smaller its chances of survival in between host crops.

Control of Root Disease in annual field crops

Crop rotation is an extraordinarily effective way of controlling almost all soil-borne diseases to which annual field crops are subject. On account of the specialisation of the more dangerous root parasites to certain groups of host species, crop rotation is most effective where botanically unrelated crops succeed one another in the rotation. Neglect of this simple precaution has led to disastrous losses through root disease in those regions where monoculture of crops has been the general rule in the past. The take-all disease of cereals, which was of negligible importance under the traditional English crop rotations of the nineteenth century, devastated great acreages of wheat in regions cropped almost continuously with this cereal in Australia and North America. Texas root rot of cotton played a similar part in the cotton areas of the southern U.S.A. Apart from incidence of such dangerous root diseases, monoculture of crops is an indefensible practice, and its responsibility for the development of widespread soil erosion in many parts of the world is now recognised. This point being conceded, then even the



Courtesy of the Indian Tea Association

FIG. 2.—Red root disease of tea: pale-coloured young rhizomorphs of the fungus can be seen covering the surface of the roots at "a".

dangerous root parasites causing take-all of wheat and Texas root rot of cotton have their use as "censors" of bad agricultural practice.

In some of these highly specialised root-infecting fungi, this disadvantage of host specialisation has been offset by the development of resting bodies, whereby the parasite can remain dormant in the soil for a period of years in the absence of a suitable host plant. Some organisms, such as *Plasmodiophora brassicae* causing clubroot of crucifers and *Synchytrium endobioticum* causing wart disease of potatoes, form single-celled thick-walled resting spores, which may remain dormant in the soil for periods of more than 5 years, and then cause infection if a suitable host crop be planted. Other organisms, such as *Sclerotinia trifoliorum*, causing stem rot of clover, form multicellular resting bodies with a protective outer rind; such sclerotia are as effective in perpetuation of the organism as are the long-lived seeds of certain notorious weeds. Comparatively little is yet known about the factors concerned in maintenance of dormancy in such resting spores and sclerotia lying in the soil. The well-known effect of lime in controlling the clubroot disease of crucifers seems to be due to its effect in inhibiting germination of the resting spores. But it would also be useful to know how such resting spores and sclerotia could be induced to germinate and die in the absence of a host plant. Various agricultural practices will probably be found to further this end; operations especially likely to be of use are soil cultivation, incorporation of certain green and other organic manures with the soil, and growth of special crops that induce the fungus to break its dormancy but refuse it sanctuary within their tissues.

Control of Root Disease in plantation crops

Crop rotation, which forms the basis of root disease control in annual field crops, is denied to the plantation grower, whose crop remains on the same site for ten, twenty, thirty years or more. It therefore behoves the plantation grower to eradicate sources of root disease from the site of the plantation crop either before planting up, or during the early years of the plantation; once the root systems of the young trees have made contact with one another, underground spread of root disease fungi becomes more rapid and more difficult to stop. Unfortunately for the tropical planter, plantations of rubber, tea, cacao, etc., have usually been established on areas cleared from jungle, with the result that the root disease fungi of the jungle trees pass to the roots of the young plantation crop. Cultivated plants are often particularly susceptible to the root diseases that they share with their wild ancestors, and their proneness to disease is enhanced by their cultivation as pure populations of a single species, which practice facilitates spread of disease from one individual to another.

Many managers of tropical plantations therefore formerly endeavoured to secure freedom from root disease by thorough digging of the site of a new plantation, and extraction of all the larger pieces of jungle root, whether obviously infected by a root disease fungus or not, before planting up. This expedient was obviously a costly one, even with an abundant supply of cheap tropical labour; nor was it always justified by subsequent freedom from root disease. When root disease did appear, the infected trees had to be uprooted and destroyed, and a quarantine area around them was usually enclosed by a trench, intended to stop the underground spread of the root-infecting fungus to the surrounding healthy trees.

In recent years, a new and spectacularly succesful method of root disease control in plantation crops has been developed by R. P. N. Napper at the Rubber Research Institute of Malaya. By Napper's method, no digging of the jungle site, and only the essential minimum of clearing, is carried out before putting in the young rubber. Subsequently, at intervals of four to six months, the young trees are inspected by a pest gang of specially trained labourers for evidence of root infection. Such inspection involves a baring of the upper tap root and laterals of every young tree; when the mycelium of a root disease fungus is discovered, it is traced to its source—a buried infected jungle root. The infected jungle root is extracted and destroyed, but the young rubber root is usually caught at a sufficiently early stage of infection for a very simple treatment to be effective. The mycelium of the root disease fungus, which is still at this stage epiphytic or superficial, is simply pulled off, and the surface of the root is rubbed with a 2% solution of copper sulphate. The success of the method depends upon the regularity of the inspections, so that potential root infections are discovered before the fungus mycelium has actually penetrated the inner tissues of the root. In this way, the young trees are themselves employed for the discovery of dangerous sources of root disease, and only those pieces of buried infected jungle root that have been met by the roots of the young plantation crop have to be extracted from the ground; much expensive digging is thereby saved.

A great advance in the control of root disease under tropical plantation crops may confidently be predicted from the recent discovery by R. Leach in Nyasaland, that much of the root disease in young plantations arises from fungi that develop on the moribund roots of the jungle stumps *after* the jungle has been felled. After felling, as Leach has demonstrated, the roots of the stumps lose their resistance to invasion by certain parasitic fungi, which develop profusely in such roots, thence to pass to those of the young plantation crop. Leach found that if the jungle trees were killed by ring-barking, a year or so before felling, then the roots were entered not by parasites, but by harmless saprophytic fungi. From subsequent work conducted by R. P. N. Napper at the Rubber Research Institute of Malaya, it seems likely that tree injection with certain plant poisons such as sodium arsenite may be used for the same purpose as ring-barking.

Control of Root Disease in glasshouse crops

Whereas most root disease problems of the farm can be solved by the practice of crop rotation, and those of the plantation by mechanical methods, the requirements of glasshouse cultivation have been met in yet another way. At the beginning of the present century, glasshouse growers were seriously vexed by the problem of "sick" soils, in which their plants failed to grow properly, despite ample provision of plant foods in the shape of heavy dressings of farmyard or stable manure, supplemented by artificial fertilisers. This condition was due in part to an unsatisfactory chemical and physical condition of the soil, caused by continued heavy manuring and watering, and in part to an accumulation of diseases and pests under the almost continuous cropping with certain highly-paying crops, such as tomatoes. Growers were unwilling to abandon the intensive culture of their highly profitable crops in favour of a more extended rotation with crops of smaller value, so that another cure for these sick soils had to be found. A practical solution of the problem was put forward by E. J. Russell and his collaborators, who showed at the Rothamsted Experimental Station that sick soils could be restored to a state of high fertility by treatment with steam, or with certain chemicals, such as formaldeyde and cresylic acid. By this practice of "partial sterilisation", the injurious micro-organisms and insect pests are killed, but the majority of beneficial micro-organisms survive the treatment, though temporarily reduced in numbers. Partial sterilisation of the soil by steam, in particular, has proved so remunerative, even in the absence of specific parasites and insect pests, as to become a routine practice with progressive glasshouse growers.

Recent research on partial sterilisation of glasshouse soils has been concerned with the problem of how best to prevent the re-entry of disease organisms and pests into the treated soils, and with the search for more effective sterilising agents. For all-round utility, steam has so far had no serious competitor, but it may eventually be displaced by a new method involving the direct passage of an electric current through the soil, if certain technical difficulties can be overcome. This method has been developed chiefly by research workers in the U.S.A.

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Spot-light on MUSEUM TE

Some thrusting criticism has recently been made of British museums—especially of those in the provinces. "Junk-houses" was one expression used; "store-houses" is perhaps a kinder expression.

Yet a museum should be more than a store-house. It should link up with the more formal expression of the education of the schools, and with public libraries and adult education.

Some of the wiser curators of our museums are alive to the educational possibilities of their charges. Few museums, however, have yet attained a standard that compels public interest and response. Some of the responsibility for this lethargy lies upon museum committees whose breadth of vision is obscured by a sacrosanct tradition. Breaking with this "store-house" complex needs courage.

Some British, American and German museums have attained a high standard of display. In the botanical field of museum technique, the work of George and Paul Marchand, who are staff artists in the Buffalo Museum of Science, New York State, U.S.A., is outstanding. We do not need to apologise for showing here some examples of their work, for they are amongst the greatest living craftsmen making artificial flowers and plants. It is reported that one day, when one of the Marchands was completing a little cluster of calopogons, a honeybee endeavoured persistently for several minutes to seek out a treasure of nectar in the heart of the model!

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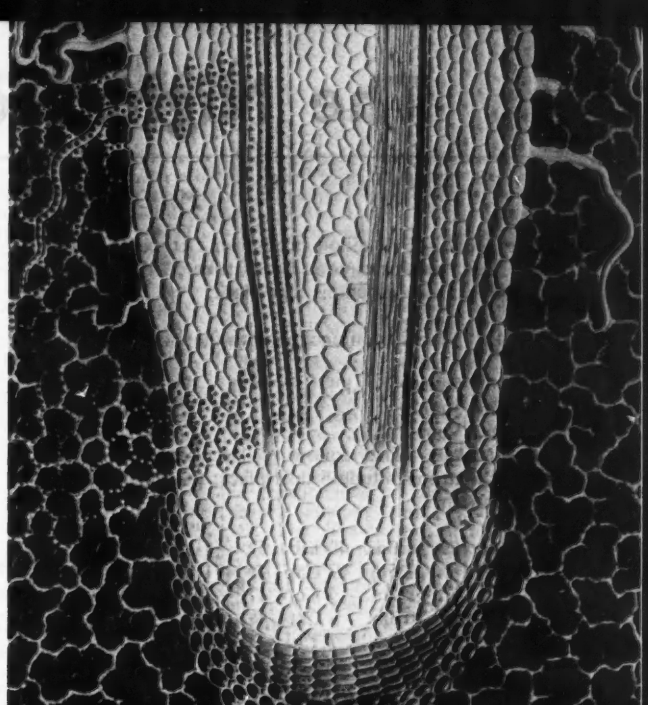
We show in Figure 1 George (*left*) and Paul (*right*) busy colouring flowers, one with a paint-brush and the other with an air-brush. In Figure 2, some idea of the number of moulds needed for a simple narcissus is shown. The moulds are placed in a hand-press and wax is poured into each in turn. For large leaves Japanese tissue or absorbent cotton supports the wax and the wire serves as a midrib. When the press is opened the leaf is stripped from the mould and its edges are trimmed. Figure 3 shows some of the marvellous life-like fungi models made by the Marchand brothers. Note at the top right-hand corner the little skull which denotes a poisonous variety! Figure 4 is the lower portion of an enlarged model of a root tip cut lengthwise with root hairs embedded in the soil. The purpose of the hairs is to increase the absorbing surface. The cells of the tip are equipped for absorbing water, minerals and gases from the soil. The root cap, which breaks the ground for the tip when it grows, is also shown. Figure 5 shows a model illustrating the circulation in a wood stem. The glass tubes represent, in the light one (which is blue in the model) water from the roots passing upward in the wood zone; and in the dark tube (which is yellow in the model) food from the leaves passing downward into the bark region.

This is but a spot-light upon a museum technique that can and should be extended to many displays other than botanical.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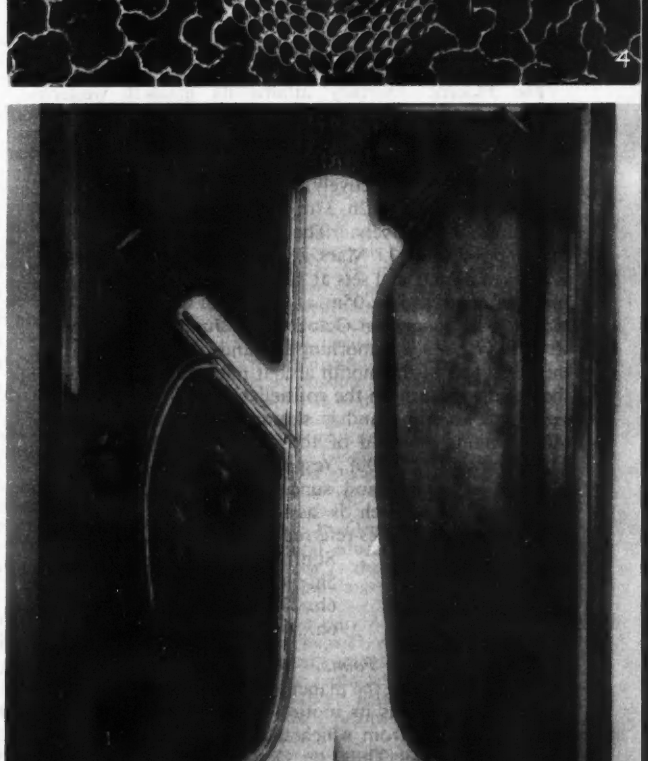
DIAGRAM OF CIRCULATION IN A WOOD STEM
THE PATHWAYS ARE INDICATED BY GLASS TUBES
BLUE - Represents water from the roots passing upward in the wood zone
YELLOW - Represents food from the leaves passing downward in the bark region
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The Night Sky in October

M. DAVIDSON D.Sc., F.R.A.S.

The Moon.—Full moon occurs on October 13d. 13h. 23m., U.T., and new moon on October 27d. 15h. 23m. The following conjunctions take place:

Oct.

18d. 04h. Mars in conjunction with the moon,

			Mars	4° N.
18d. 14h.	Saturn	,, ,,	Saturn	2° N.
23d. 07h.	Jupiter	,, ,,	Jupiter	0°·2S.
25d. 03h.	Venus	,, ,,	Venus	4° S.

Occultations.—The following occultations of stars brighter than magnitude 6 take place; the times referring to Greenwich:

				a	*b*
Oct. 3d.	18h. 01·0m.	49 Lib	D	−1·1	−1·4
8d.	18h. 43·5m	19 Cap	D	−1·3	+0·9
15d.	02h. 59·2m.	μ Cet	D	−1·3	−0·2
15d.	04h. 10·3m.	μ Cet	R	−1·0	−0·6
15d.	22h. 17·4m.	*f* Tau	D	−1·3	+0·6
15d.	22h. 58·6m.	*f* Tau	R	−0·1	+3·0
17d.	01h. 26·5m.	γ Tau	R	−1·0	+2·2

(D and R mean disappearance and reappearance, respectively. The use of the symbols *a* and *b* is explained in DISCOVERY for August.)

The Planets.—Mercury attains its greatest western elongation on October 10. The planet is a morning star and at the beginning of the month rises at 5h. and sets at 17h. 10m. At the end of the month the times are 6h. 15m. and 16h. 27m. respectively. Venus is a morning star, rising at 3h. 17m. and 2h. 37m. at the beginning and end of the month respectively. The planet attains its greatest brilliancy on Oct. 13. Mars, in the constellation of Taurus, is an evening star and sets at 12h. 32m. at the beginning of the month and at 11h. 05m. at the end of the month. The planet is stationary on October 28. Jupiter, in the constellation of Leo, is a morning star and rises at 1h. 30m. at the beginning of the month and at midnight at the end of the month. Saturn, in the constellation of Taurus, can be seen close to Mars, and is stationary on October 9. At the beginning and end of the month the planet sets at 12h. 40m. and 11h. 10m., respectively.

Times of sunrise and sunset are given below. The latitude of Greenwich is assumed for the rising and setting of all the bodies referred to.

	Sunrise	Sunset
October 1	5h. 59m.	17h. 40m.
,, 15	6h. 22m.	17h. 09m.
,, 31	6h. 50m.	16h. 37m.

Note on Stationary Points.—Stationary points are those points in the orbit of the planet at which the body appears stationary as regards its motion in longitude among the stars. The point from which the planet is viewed is, of course, the earth. Thus, on October 9 Saturn will no longer continue to increase in longitude as viewed from the earth, but will appear to be stationary for a short time and will then appear to decrease in longitude. The same applies to Mars on October 28. This appearance is due to the motion of the earth round the sun, as a simple diagram will show. A superior planet—one at a greater distance from the sun than the earth is—has a slower orbital motion than the earth, and when it is near opposition the earth is overtaking the planet or leaving it behind. For this reason the planet retrogrades, and hence when a superior planet has retrograde motion we know that it is not very far from opposition.

The motions of the planets, direct, then stationary for a time, then retrograde, were very puzzling to the ancient astronomers, who could only explain such erratic movements by supposing that each planet moved on the circumference of a small circle—the *epicycle*—the centre of which described a large circle—the *deferent*—around the earth. In this way each planet looped a loop in a certain time, as we see it does to-day, but when the heliocentric theory was accepted in the 16th century it was unnecessary to postulate all the complicated movements of the planets.

The Autumn skies provide so many interesting objects for the amateur with a small telescope that it is difficult to give more than a few of the most important of these. The quadruple system ε Lyrae can be seen with slight optical aid and is a beautiful sight. The variable star ζ Lyrae has a period of nearly 13 days with a range of magnitude from 3·4 to 4·3, and those who have time to observe it will be amply repaid for their trouble. The neighbouring constellation of Cygnus has many interesting objects. Its brightest star, Deneb, is an enormous sun about 10,000 times as brilliant as our own Sun, but it appears to us just as a first magnitude star, like a number of others, because of its great distance—it is 650 light years away. Then there is β Cygni, which many astronomers consider the finest double for amateurs. Its components are orange and blue, the magnitudes of each being 3·2 and 5·4. The rather obscure star 61 Cygni should be noticed, because, obscure as it is, it has two very important distinctions. In the first place it was selected by Bessel, in 1838, to find its distance from the earth, being the first star to be chosen for this purpose. His attempt succeeded, and when his work was completed it was shown to be comparatively close to us—only about 11 light-years off. Then it has the distinction of being the first star, outside our sun, which is known to have a planet associated with it (see DISCOVERY, IV, 132). The brilliance of the Milky Way in Cygnus is very noticeable, and the great "rift" in it can be seen quite distinctly. It is not devoid of stars, as its appearance suggests, but is due to vast masses of obscuring matter which cut off the light of the stars beyond. Proceeding downwards along the stream of the Milky Way we reach the constellation of Aquila, and observations on η will show that it varies from magnitude 3 to 4 in a little over a week. Even the beginner will notice that stars of all magnitudes are much more numerous in or near the Milky Way stream than they are in other parts of the heavens.

The Bookshelf

The Metabolism of Fat. By IDA SMEDLEY-MACLEAN, M.A., D.Sc., F.I.C. (Methuen and Co., London, 1943; 104 pages; 5s.)

THIS book is the latest addition to Methuen's Monographs on Biological Subjects, a series well-known to all interested in this field of science. The publishers state that they are intending to give brief authoritative accounts of current biological knowledge to teachers, students, research workers and general readers with a taste for biology. The book must, therefore, be assessed on this basis.

Early speculations regarding the fate of the fat we eat in our food have suffered considerable modification and extension during the last quarter of a century. New ideas have been put forward, and the problems have been tackled with refined techniques and with radically new weapons. In this connection may be mentioned the use of deuterium ("heavy hydrogen"), and elements artificially made radio-active, to label fatty substances in their passage through the body. To-day, many of the difficulties remain; many of the conflicting theories are unproved. In these circumstances the author is to be commended for compiling such a stimulating account of the present situation.

Briefly, the fat in an animal's food is split during the course of digestion into fatty acids and glycerol. After passing through the intestinal wall, these components recombine and enter the blood stream. In addition, the body can convert carbohydrates into fats by a mechanism, the details of which are still incompletely understood. An interesting feature of these processes is that only fatty acids with an even number of carbon atoms, such as palmitic ($C_{15}H_{31}COOH$) and stearic ($C_{17}H_{35}COOH$) acids, are formed. Some of the fat from the blood stream may be deposited as part of the animal's reserve, and the rest is consumed to yield energy.

More specifically, the topics discussed include: biological synthesis of the fatty acids, constitution and action of the polyene unsaturated acids, oxidation, methods of combination and method of transport of the fatty acids.

To a reader well versed in scientific nomenclature the text would provide little difficulty, but for the benefit of the general reader, additional explanations or footnotes would prove valuable. For example, more formulæ would be useful to assist him in appreciating the nature of some of the chemicals named, while many of the empirical formulæ given might well be elaborated to the customary abbreviated form, as used above. A number of biological terms and names merit further elaboration.

Few errors have been detected in the text, but reference should be made to the formulae on pp. 78 and 79; and on p. 4, line 8, the words "carbohydrate" and "fatty acids" appear to have been reversed. Thiele's theory of residual valency has long since given place to the modern electronic concepts of organic chemistry, so it is surprising to find it resurrected in a discussion on the formation of oleic acid (p. 12). The index provided is scarcely adequate to cover a book so full of information. Numerous references to the literature are given, but they must not be accepted as exhaustive. They do, however, furnish valuable starting points for a more detailed study.

These criticisms are not intended to obscure the general excellence of this little book, which may be confidently recommended, with the reservation that the general reader will find it "heavy going".

ALAN D. SCOTT.

An Encyclopaedic Dictionary of Science and War. By SURGEON REAR-ADMIRAL C. M. BEADNELL, C.B. (Watts & Co. Ltd., London; pp. xviii + 294; 25s.)

SURGEON REAR-ADMIRAL C. M. BEADNELL need no longer worry about his being "turned down" by the Admiralty on account of his age and thus not being able "to do his bit". If the compilation of this book is his rejoinder to the Admiralty's decision, then the Admiral has scored with a full broadside. Within its compass it is a worthy piece of work.

The encyclopædia has as its object the linking of science to war, and in alphabetical order deals by means of short notices or longer articles and tables with some thousands of items. It ranges over the many fields of science that are cultivated by Mars to supply his modern needs of warfare. Astronomy, light, heat, chemistry, electricity, magnetism, sound, zoology, botany, meteorology are but few of the many aspects of science harnessed to modern warfare.

To the busy man needing a practical up-to-date quick reference to the many technical terms and phrases that the war has conceived or brought to public notice, this book is just the thing. The non-specialist user will get all the information he requires in an assimable manner, even if he is at first a little frightened by the occasionally formidable array of abbreviations, figures and formulæ.

That there are bound to be a few slips in a book of this nature is anticipated by the author. There are, too, some omissions that perhaps are a little surprising; but then the task of selection must have been enormous. Nonetheless we anticipate that this *Encyclopaedic Dictionary of Science and War* will become a favourite book of reference by its users.

P.V.D.

Sweden Speaks. By GUSTAV WITTING. (Allen & Unwin, London, 1943, 212 pages; 8s. 6d.)

THIS collection of essays in various aspects of English life written by fifteen Swedish scholars in the fell summer of 1940 might well have been England's epitaph. Instead we can welcome it in translation as a monument to Sweden's understanding. What other nation could have produced even in peacetime so subtly penetrating a conspectus of English institutions and culture? And when will English scholars produce an equivalent synopsis of a continental country? (One remembers the old gibe: "England takes no interest in foreigners; she takes it from them.")

These essays are as free from gibes as they are from inaccuracy or fulsome flattery. The worst that can be said of them is that two of the writers—those on "The Senior School" and on "British Sport"—are naive, a serious fault in work of this nature. But in all symposia the contributions are uneven, and the general standard here is remarkably high. The best essays are those on political constitutions and the spirit behind them. Professor Liljestrand's all-too-short paper on "Medical Research in England" may be of a special interest to readers of DISCOVERY.

J.H.J.

The Place of Glass in Building. Edited by JOHN GLOAG, Hon.A.R.I.B.A., with contributions by LIONEL B. BUDDEN, M.A., F.R.I.B.A., and G. A. JELLICOE, F.R.I.B.A. (Allen & Unwin, London, 1943, 90 pages; many illustrations; 7s. 6d.).

"BUT glass as a structural material, is not just a window-filler." That one sentence, appearing in the middle of page 11 of this fine little book, sums up adequately the theme of Mr. Gloag's argument.

In an opening 3000-word essay the Editor argues his case logically and convincingly. He quotes Professor Walter Gropius for support for the view that "new synthetic substances—steel, concrete, glass—are actively superseding the traditional raw materials of construction. Their rigidity and molecular density have made it possible to erect wide-spanned and all but tranparent structures, for which the skill of previous ages was manifestly inadequate". From this baseline, Mr. Gloag builds up a well-documented evidence, supported further in the book by well-chosen illustrations.

The Editor's essay is supported by one by Mr. Budden in the place of glass in architectural education, and another by Mr. Jellicoe in the use of glass in small standard buildings. Both are invaluable little studies.

The best part of the book, however, begins on page 27, when the manufacture, preparation, specification, uses, and all the many technical details of different kinds of sheet, plate, rolled and special glass are meticulously treated and illustrated.

To the architect, builder, surveyor—whether "in practice" or teaching in technical colleges—the book is invaluable. And to students, it's a godsend.

P.V.D.

Far and Near

Training of Government Scientists

No person without adequate scientific or technical training should be placed at the head of a Government laboratory or technical establishment. Certain higher administrative posts should be filled only by officers of high scientific attainment. Government research would benefit by a more rapid influx of new blood and the transfer of some members of scientific staffs to administrative work where they show greater aptitude for such duties than for research. These are a few of the suggestions made in the latest report of the Parliamentary and Scientific Committee concerning the training of scientists in government service. The report also comments on the unfortunate position of personnel of the Assistant grade who, by attending evening classes, obtain their B.Sc. degree only to find that the rigid establishment of their branch of the service prevents them being promoted to a higher rank; such qualifications as a degree are not always considered to be a claim to promotion, and although their qualifications have improved their work remains the same and remuneration is related to that work. In any event intensive study at evening classes after a day's work is not a desirable method of obtaining such training, and there should be schemes to enable scientific Civil Servants to take university degrees by normal attendance at a university. For others a system of suitably sponsored National Certificates taken through classes at a technical institution would provide valuable training.

Possibly the most valuable comments are made with regard to making good the anomaly whereby promotion on the scientific side is slower than on the administrative side of the Civil Service, specific recommendations being put forward to remove the factors which prejudice the scientist who enters Government service. The report argues that some of the administrative posts require adequate knowledge of a particular science. It is suggested that, as a matter of policy, the progress of young Government scientists should be observed with a view to singling out those who show a preference and aptitude for administrative work. At the age of 35 or less such officers should be offered administrative posts, and this should be regarded not as promotion but as transfer to a more suitable job. By adjusting the grading of scientific staffs, it should be made possible for a scientist who is suited to remain in a scientific post to do so without financial loss; then he would not be attracted to administrative work through the discrepancy between administrative and scientific scales of pay. By providing the means for transferring those less suited to scientific work room would be made for a greater intake of young scientists into the Government service; by simultaneously widening the avenues of advancement Government service would be made attractive for them. Work in Government research departments would benefit by a more rapid influx of new blood.

Another important recommendation is that the provision of a common pension scheme should be considered, so that transfer and exchange of personnel between Government establishments, universities, research institutions and industry would be possible. The report also mentions that consideration should be given to the employment of scientific staff and scientific attachés at our embassies and legations overseas.

Rehabilitation of European Agriculture

THE Inter Allied Post-War Requirements Committee has made preliminary estimates of the livestock which will need to be provided if European agriculture is to build up its former herds of cattle. At the outset it is reckoned that British farmers will be asked to contribute 500 pedigree bulls for breeding purposes; these would primarily be of the dairy type, but some consideration would have to be given to the possibilities of dual-purpose animals suited both to milking and draught work. America, the Dominions and the Argentine are likely to be asked to supply from 750,000 to 1,000,000 "utility" cattle capable of yielding milk while performing farm haulage tasks as well. These figures are expected to cover the first two post-war years. For the transportation of these huge stocks, it is planned to convert anything up to 200 vessels of 400 to 500 tons into cattle boats, and another 150 boats would have to be partially converted.

Cabbage Butterfly Pest Returns

FROM all reports it seems evident that the vast invasion of the destructive cabbage white butterflies that plagued our fields and gardens last year has returned, in equal if not greater strength. Along the East Coast voluntary watchers gave warning of this new "invasion". So numerous were these vast hordes of butterflies becoming that the observers are asked to notify experts at Norwich whenever they saw a cloud approaching so that the farmers could be warned to spray their crops with tar oil to safeguard them. Near Felixstowe one swarm of butterflies took nearly 20 minutes to cross the coast, while huge numbers have also been seen near Oulton Broad.

The Immigration of cabbage whites is not new; a big invasion took place in 1937. Nor is it unusual for them to travel across the North Sea; it is known that whole masses during migration may alight on the surface of the water to rest for a while. Clearly some new method of combating the menace these insects constitute is needed. Although the life of one butterfly is only about 25 days, the number of eggs that are laid during that time on the leaves of cabbages, etc., is enormous. In hot weather the larvae emerge in a few days and start their destruction.

At present, antidotes consist mainly of spraying the crops before the eggs are laid, or hand-picking the eggs or grubs afterwards, which is not very economical. The natural enemy of the cabbage butterfly is the ichneumon fly, which lays its eggs in the eggs of the butterfly. They hatch into larvae, which live a parasitic existence in the caterpillar's blood until it is full grown when, they kill the caterpillar by gnawing a hole through its side and form a mass of yellow cocoons outside which hatch later into more useful flies. Although they do not eradicate the caterpillar in the first generation, as it were, they do represent a potential destroyer of millions of cabbage white caterpillars. It seem feasible that some method of control could be evolved using these beneficial flies.

Spanish Bibliographies

PLANS for the co-ordination of bibliographical material go on apace in all directions. Last year the Instituto Nicholás Antonio de Biografia was set up in Madrid with the object of organising and disseminating news of Spanish biography. This has taken the form of a publication *Bibliotheca Hispana*, the subject-matter of which is divided into three groups, one volume dealing with each group being published every three months.

The first subject-group comprises general works, bibliography, religion, philosophy, ideology, statistics and demography, sociology and politics, political economy, and law. The first section of this particular volume (the first of the series) deals specifically with Spanish publications, whilst the second—under the same headings—includes works of foreign (including British) origin. The third section comprises an essay on "Orientaciones bibliograficas sobre filosofia," by Juan Francisco Yela.

The second subject-group deals with pure and applied science, whilst the third covers philosophy, literature, art, geography and history.

If subsequent volumes to the first of its series maintain the prototype standard, then the work of the Instituto Nicholás Antonio will win international fame.

Personal Notes

As a tribute to the memory of DR. GEORGE SENTER, the late principal of Birkbeck College, who died last year, it is suggested that a research laboratory for physical chemistry should be established at the college. Dr. Senter left £1000 to the college in his will and the governors propose to use this as the nucleus of the research laboratory fund.

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SIR HENRY TIZARD the aeronautical expert who is President of Magdalen College, Oxford, is leaving England on special duties for two or three months, and has resigned from the Air Council and the Aircraft Supply Council of the Ministry of Aircraft Production.

DR. W. B. R. KING is to succeed MR. OWEN T. JONES as Woodwardian Professor of Geology at Cambridge.

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MR. F. F. RENWICK, Research Director of Ilford Limited, died on the 14th August after a brief illness. He was an outstanding figure in contemporary photographic science. His association with the photographic industry in this country reached back to the turn of the century (he joined Ilford Limited as a chemist in 1898), and during the forty-five years which followed he made many important contributions to his subject.

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DR. C. M. WENYON, who has been associated with the research laboratories of the Wellcome Research Institution for 36 years, is retiring shortly. He will hand over the direction of the Institution to DR. CHARLES H. KELLAWAY of the Walter and Eliza Hall Institute for Medical Research, Melbourne. Director of the Wellcome Bureau of Scientific Research, for which Dr. Wenyon has also been responsible, will be DR. N. HAMILTON FAIRLEY, until recently a director of medicine to the Australian Army in the Pacific.

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PROFESSOR ALBERT EINSTEIN has joined the United States Navy Ordnance Bureau and will do research work on the phenomena governing the detonation of explosives.

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THE Government has appointed two commissions to inquire into higher education, firstly in the Colonies, and secondly in British West Africa. Scientists on these commissions include PROFESSOR H. J. CHANNON, professor of biochemistry at Liverpool until recently; PROFESSOR A. V. HILL, M.P. for Cambridge University and secretary of the Royal Society; DR. R. V. SOUTHWELL, rector of Imperial College of Science and Technology; SIR GEOFFREY EVANS, until recently acting director of Kew Gardens; DR. JULIAN HUXLEY; PROFESSOR A. E. TRUMAN, professor of geology, Glasgow University; and PROFESSOR J. A. RYLE, professor of social medicine, Oxford University.

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PROFESSOR LANCELOT HOGBEN has just completed a book of nearly 300 pages in which he describes a new international language he devised during nights of fire-watching at Aberdeen University, where he was professor of geology before moving to Birmingham. The work represents the 301st attempt that has been made to solve the problem of breaking down the Tower of Babel.

Photography and Science

THE increasing importance of photography to science and industry merits the growing attention given to this subject. Messrs. Ilford have just re-issued their booklet *Photography as an aid to Scientific Work* in a seventh edition. In this latest edition the information gathered through a number of years in the Ilford laboratories is brought up to date. It also gives details of the latest Ilford preparations.

Inquiry into Behaviour of Metals

A GOOD deal more is understood nowadays about the behaviour of metals under loadings. Squadron Leader A. C. Vivian, D.Sc., in a paper "A Renaissance of Mechanical Properties" just published by the Institution of Mechanical Engineers, puts forward an analysis of the present position as he sees it. The true origin of these properties has now been discovered, he says, which is the four-dimensional relationship between stress, strain, temperature of loading, and rate of loading. If temperature and loading rate are assumed to be fixed at some normal value for each, the standard stress-strain curve of the material remains.

The popular "nominal" diagrams of stress-strain have never awakened an appreciation of their significance for the properties: nor could they do more than camouflage that significance and hide the facts. For, the nominal curves differ in every different type of loading, and thus present insuperable difficulties in reading that story of the mechanical properties which is unfolded by the one true curve for all types.

If proper calculations are made to ascertain the effective cross-sectional area and the effective length, the one true stress-strain curve of pure unidirectional axial loading is found to hold good for all types of loading in which lateral strain is unrestricted. The isolation of this one curve, which can also be condensed as six numerical terms, now permits the production of complete evidence of the true mechanical properties of the material to which it relates. From it can be obtained at last not only the real values of the modulus, limit of proportionality, elastic limit, proof stresses which are but slightly different, but also greatly differing real values for ultimate tensile stress, fracture stress, ductility up to the point of fracture (as usual), ductility up to any desired point of the curve, and toughness at fracture or at any other point of the curve.

Notch Toughness, Creep Resistance, Fatigue Endurance and Hardness have all, as he states, suffered in their way under the old "nominal" or obscure regime; these can be viewed from the standpoint of the true curve, and thus brought into line until the one true stress-strain curve can be regarded as a complete graph of all the mechanical properties whatsoever. This view is said to solve some paradoxes, to remove endless difficulties, and to promise progress hitherto impossible.

Sir John Clark Ross

ONE hundred years ago the explorer, John Clark Ross, and his companions returned from one of the most fruitful of Antarctic expeditions.

This period, in the last century, saw considerable progress in the field of Antarctic exploration. Franklin and others had done much to survey the Polar regions, and the British Government had taken considerable interest in these discoveries. Up to this time, the South Polar regions had not been explored to any great extent, but the Antarctic snows had already claimed some brave lives, including that of Franklin.

Ross had already done some notable work. He had previously discovered the North Magnetic Pole, and had afterwards worked from 1835 to 1838 on the magnetic survey of Great Britain. A year after concluding this survey, he set out with two ships provided by the British Government. These were the *Erebus* of 370 tons and the *Terror* of 340 tons. Both of these ships were specially built for work in ice. The chief purpose of the expedition was the survey of the magnetic meridian in the Antarctic regions. The first land the expedition discovered was Victoria Land, and after further discoveries the expedition returned to base for the winter. Later, the ships returned to polar waters and unofficially discovered King Edward Land, but Ross was not certain of its existence, and so confirmation of his discovery had to be left until the twentieth century.

Ross was born in London in 1777, elected F.R.S. in his 67th year, and died 12 years later.

The Hamburg X-ray Apparatus

BRITISH Scientists will be wondering whether the high power X-ray therapeutic installation at Hamburg still exists. This X-ray apparatus which was, according to an article in the January number of the Argentine *Revista Electrotecnica*, constructed in Berlin after a series of careful experiments, is (or was) the most notable X-ray installation in the world. It is (or was) housed in a specially constructed building in the Hamburg-Barmbeck hospital. A current of 5 milliamps. is utilised and a continuous and steady tension of about 1,000,000 volts is attained in the production of the X-rays.

The apparatus, which stands about 21-ft. high, has the advantage of being able to maintain a tension of constant power. High tension is raised by means of a system of high-tension condensers and electric valves with large vacuums. The tube itself stands about 15ft. high and has six distinct sections each connected to a corresponding section in the high tension generation.

The vacuum which it is necessary to maintain in these tubes is obtained by pumps which work while the apparatus is functioning. The electrons reach a velocity of 285,000 km. per sec. in the anode.

Changing the cathode filament, when it is burnt out, is accomplished in an ingenious way. Eight filaments are fixed and as each one lasts 3 months, working 7 hours daily, the cathode will last 2 years.

The cylinder of the tube is made of a special glass of very high quality 10 mm. thick, and the anode is covered with lead which prevents unnecessary radiation.

The great power of this apparatus, together with a current of 5 milliamps. and a tension of 1.2 million volts (6 kilowatts), allows a diffusion up to 6 yards. The treatment room is some 15 ft. below ground level, thus assuring necessary protection against the rays.

More Dehydration Plants for Britain

LORD WOOLTON recently detailed his plans for increasing the number of dehydration plants in this country. He said that the Ministry of Food was aiming at the erection of thirty such plants: twenty-two had already been ordered, three were in operation and eleven were under construction. Imperial Chemical Industries Ltd. would undertake the erection of the plants on behalf of the Ministry and the plants in course of erection would be brought into production over the next three months. There was, however, little prospect of their output being available for the public, as all dehydrated vegetables would be required for the Forces.

From America, however comes a report that a dehydrating apparatus which can be used by the ordinary housewife has been designed and is now on the market.

Penicillin Research in Canada

PENICILLIN is being produced in the Banting Laboratories, Toronto, and Dr. T. H. Grey, who is in charge of penicillin research at that institution, said last month that the first production in quantity was going to the armed forces, adding that it would be a year before it be available in sufficient quantities for distribution to the medical profession for civilian use. He commented: "The laboratories here are obtaining the largest quantities of the agent yet obtained from the mould. Everywhere now they are getting a bigger quantity than at the start. We understand better how to feed the mould to produce more penicillin. Its potency is so great that even in a dilution of 1 part of the agent to 1,000,000 parts of sterile water, it will kill disease organisms."

Sir John Anderson, Lord President of the Council, during his recent visit to America told reporters in Washington that as a result of Anglo-American scientific co-operation it was hoped to obtain large supplies of penicillin. Quantity production could be expected early next year. Substitutes for quinine were not yet in adequate supply, he said, but all efforts were being made to strengthen this weak link in the Allied armour.

Presumably with penicillin production in mind, Sir Robert Robinson, who is in charge of a penicillin research team at Oxford, wrote a letter to *Nature* last month (August 7, page 162) suggesting a method that might be tried with a view to increasing the yield of bacteriostatic agents from moulds. He wrote: "In view of the variability of many fungi and the possibility that moulds and bacteria may be mutually biologically antagonistic when growing in the same medium, it is perhaps not too fanciful to suppose that repeated cultures of a mould and pathogenic bacteria together may develop increased production of bacteriostatic metabolic products of the former. Various forms of the assumed antagonism can be imagined, and competition for a common growth-promoting factor is probably the simplest. Furthermore, provided such antagonism exists, it is easy to see that in still or viscous media the mycelial nuclei that contained cells producing the bacteriostatic substance would have the greater survival value. I . . . think it would be worth while to try to produce bacteriostatic substances against selected pathogens by repeated mixed cultures, using a variety of moulds for the purpose."

Sodium in the Air

METALLIC sodium is playing a part in American aero engines, being used in the automatic self-cooling exhaust valves which are fitted to practically all engines of over 300 h.p. in military planes. These valves can take the tremendous shock of the violent detonations and pre-ignitions of the modern plane. According to a statement of the American chemical firm du Pont de Nemours, the coolant—sodium—is sealed tightly in the interior cavity of the valve. As the engine operates the valve head is heated by the combustion of the gases. This heat melts the sodium and the motion of the valve sprays the liquid sodium over the entire inner surface of the head cavity, so absorbing the heat which is then dissipated through the stem guide to the cylinder and the cooling system

Artificial Insemination Control

REGULATIONS controlling the application of the technique of artificial insemination have been made by the Minister of Agriculture and the Secretary of State for Scotland. The regulations, which come into operation on November 1, prohibit the distribution or sale of bull semen except under licence. The Scottish regulations apply also to the semen of stallions, and specify the conditions attached to the granting of licences. The purpose of the regulations is to bring under strict control the practice of artificial insemination, in order to ensure that it is not developed on wrong lines. Pending the results of large-scale field experiments now in progress, the Minister and Secretary of State are not prepared to offer any financial encouragement, and consider that any wide expansion of the practice at this stage would be premature. The regulations, naturally, cannot and do not attempt to restrict artificial insemination of a dam in the same ownership as the sire from which the semen is collected.

Silica gel stops Corrosion

SILICA GEL is being used to prevent corrosion of aircraft and other engines during their transit to a theatre of war. The sparking plugs are removed from the cylinder cases of the engines and replaced by transparent containers, of the same size and filled with silica gel. The silica absorbs moisture, and a humidity indicator attached to each shipping container enclosing an engine tells whether the silica gel is doing its job. These indicators consist of a quantity of silic gel particles impregnated with cobalt chloride; when the silica has adsorbed the optimum amount, the relative humidity rises and registers a colour change in the cobalt chloride. The moisture-absorbers in the engines must then be replaced. Use of this material avoids the coating of corrodible metal parts with thick grease, which had hitherto been used to stop corrosion but which was found difficult to remove when necessary.

Testing Drugs with Phosphorescent Bacteria

A NOVEL technique for comparing the effectiveness of different bacteriostatic agents of the penicillin type is being tried in America. Instead of testing the lethal effect of such agents on disease-producing bacteria, a luminous bacterium —called *Photobacterium fischeri*—is used. When sea water containing a nutrient such as peptone is inoculated with this organism a bacterial suspension is obtained that has a phosphorescent glow. To find the quantity of a bacteriostatic agent required to kill the bacteria, all that is necessary is to add various measured quantities of the agent to the sea-water suspension of bacteria and then see what is the smallest amount that has quenched phosphorescence. Assays made by this method give results that run parallel to those obtained by using more customary bacteria such as Streptococcus pyrogenes. An account of the method as used for testing the antibiotic activity of aspergillic acid is given in *Journal of Bacteriology*, 1943, 45, 5, p. 461.

Gangrene in the Present War

TREATMENT of battle wounds has progressed to the stage where gangrene infection appears to have been almost eliminated. This fact was disclosed in a recent number of *The Lancet* by a medical corps officer, Major J. D. Maclennan, who stated that in the six campaigns in the Middle East from the outbreak of war up to the second battle of El Alamein there were only 164 cases of gangrene (73 fatal) among the total casualties which numbered 37,699.

Plastic Grenades

THE technical detail of the manufacture of the No. 69 grenade from plastics have now been released in this country. Filled with high explosive it is detonated by percussion in landing. It is moulded of medium impact cotton-flock and wood-flour filled phenolic, it conforms to the usual rigorous war-material specifications. This plastic material is dimensionally and physically stable in a temperature ranging from −40°F to +170°F. It is also unaffected by the explosive materials with which it is packed, and by the weather, water or mud.

It is stated that this No. 69 grenade is almost a duplicate of that designed and produced in this country, the manufacturing of which was developed in Canada. A full description is in the August number of *British Plastics*.

A New Penguin Magazine

TRANSATLANTIC, a new shilling monthly edited by Geoffrey Crowther and published by Penguin Books, Ltd., makes its bow this month. The first number contains an array of articles from prominent American writers, including one by Ellsworth Huntington, one of the leading climatologists in the States.

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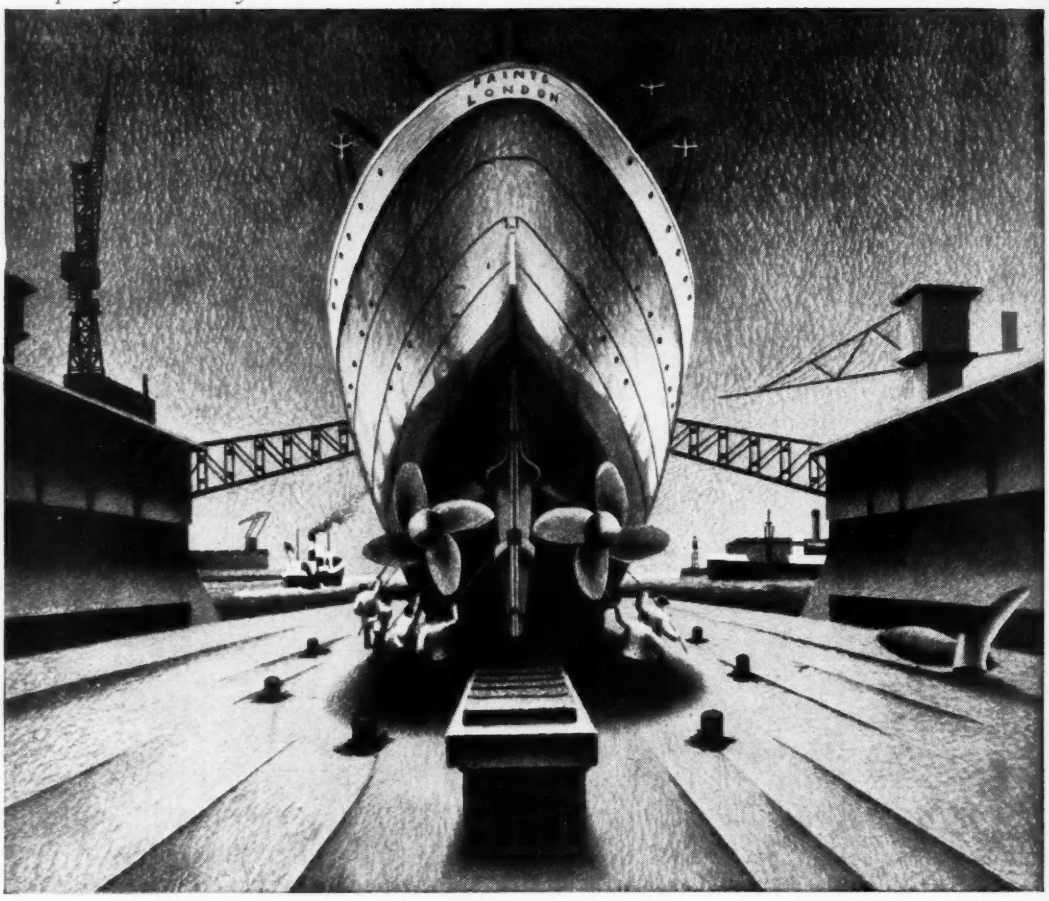

CORROSION

AN eminent British metallurgist estimated that every year in the world some 30 million tons of steel become unusable by corrosion, that is by rust. This figure must largely be guesswork, but it is an impressive reminder that, though modern skill and knowledge have enabled the builder and engineer of today to improve on the work of their fathers, their greatest achievements are still wasting assets. Steel and cement may replace wood and brick, but for all their strength and hardness, they are not immune from decay. They need protecting from the effects of the atmosphere, from sun and wind and rain and sea water. It is one of the duties of the chemist to see that this protection is given in the shape of better and still better paints. Until recent years paints were simple materials, made from linseed oil or pigments such as white lead. Modern research has completely changed the picture. Today the discovery and production of new protective coverings is a highly scientific part of the British chemical industry, dealing with an ever-growing variety of chemical substances which provide the bases for new resins, lacquers, and finishes: paints specially designed to prevent rust, to stop decay in wood, to resist heat, to imitate stone; lacquers for metal work; dopes for aeroplane and balloon fabrics; finishes of every sort for every sort of article. If protection is in a sense the first requirement of a paint, decoration comes a close second. The demand for more and brighter colours has been steadily growing for years. It has been at once stimulated and satisfied by the happy collaboration between the paint chemist and his opposite number in the dyestuffs and pigment industries. Together they have enabled colour to be applied to a constantly increasing number of articles used in daily life. They contributed to a more gaily coloured world. War has temporarily shrouded their work, but when Peace comes again, they can be relied on to give still better colour worthy of the new world that will be

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